Late Holocene sedimentation in Iberian Range karstic lakes: Facies model, depositional evolution and climatic implications

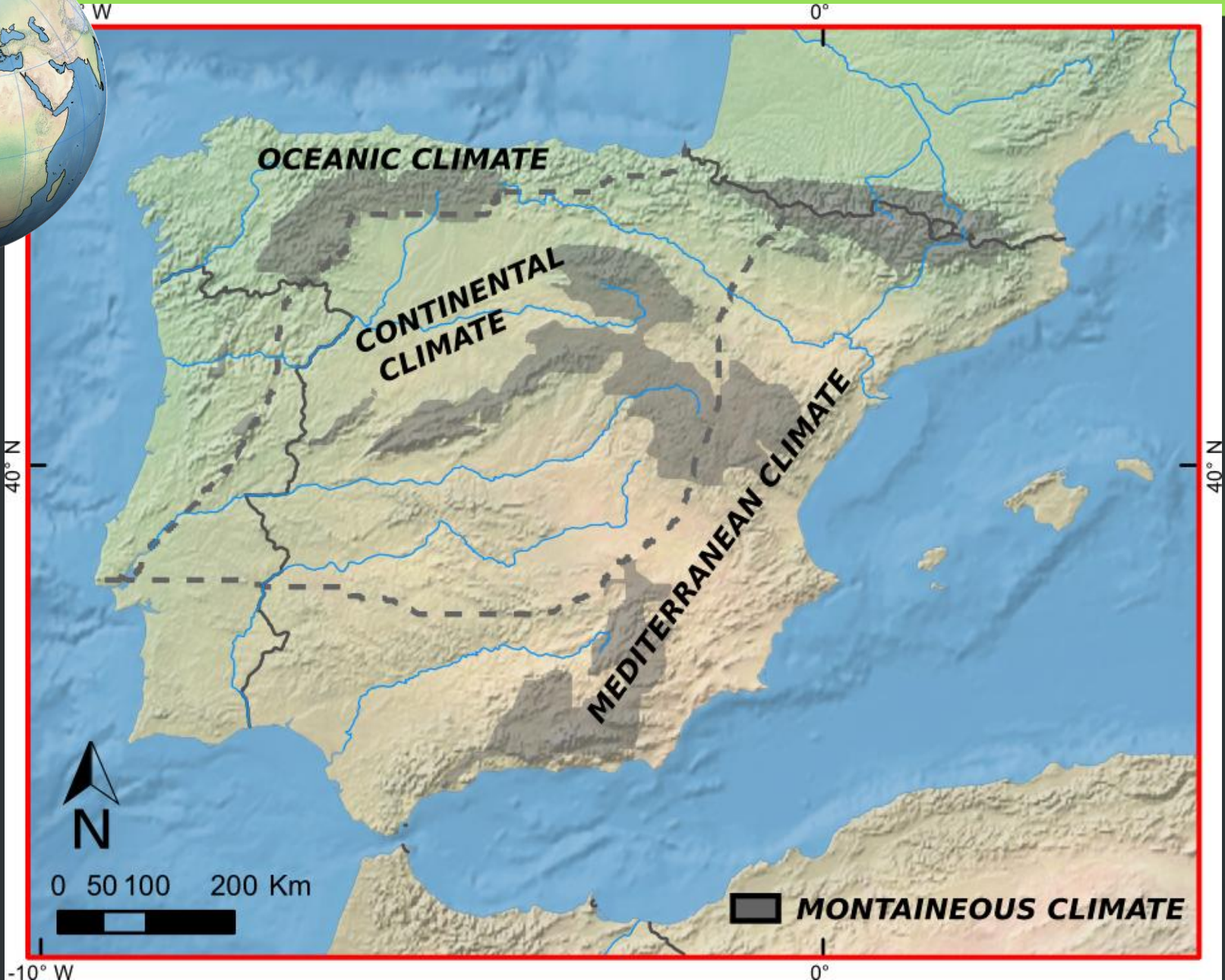
F. Barreiro-Lostres * Pyrenean Institute of Ecology, CSIC, Spain
A. Moreno Pyrenean Institute of Ecology, CSIC, Spain
S. Giralt Earth Sciences Jaume Almera Institute, CSIC, Spain
P. Mata Spanish Geological Survey (IGME), Spain
J. Aranbarri Pyrenean Institute of Ecology, CSIC, Spain
B. Valero-Garcés Pyrenean Institute of Ecology, CSIC, Spain

Mediterranean Records in karstic terrains…

also small lakes and short sequences

- The potential of small karstic lakes
- Facies as paleohydrological tools
- Climate and Human interactions during the last millennia

The Iberian Peninsula:climates



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Lacustrine Records

Montcortès Corella et al. (S12-P02)

Banyoles Morellón et al. (S12-P05)

Basa Mora Moreno et al. (S12-P09)

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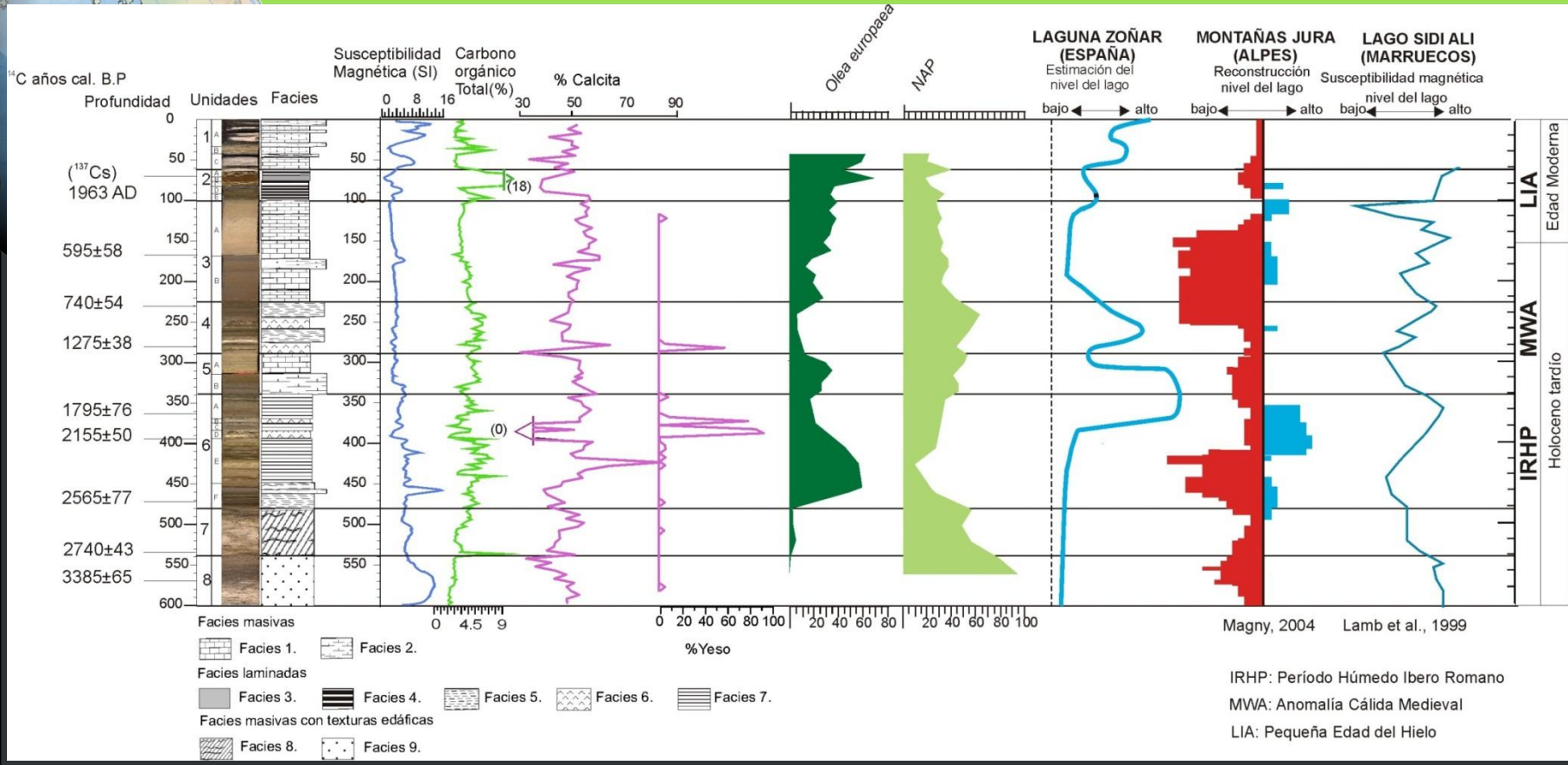
Introduction & Location

Zoñar Lake (southern Spain)

Martín-Puertas et al.,(2008, 2009, 2010)



- Arid period prior to 2.8 BP
- Iberian – Roman Period → humid (2.5 – 1.5 ka BP) (with a dry phase around 2 ka BP)
- Arid MCA
- Humid LIA

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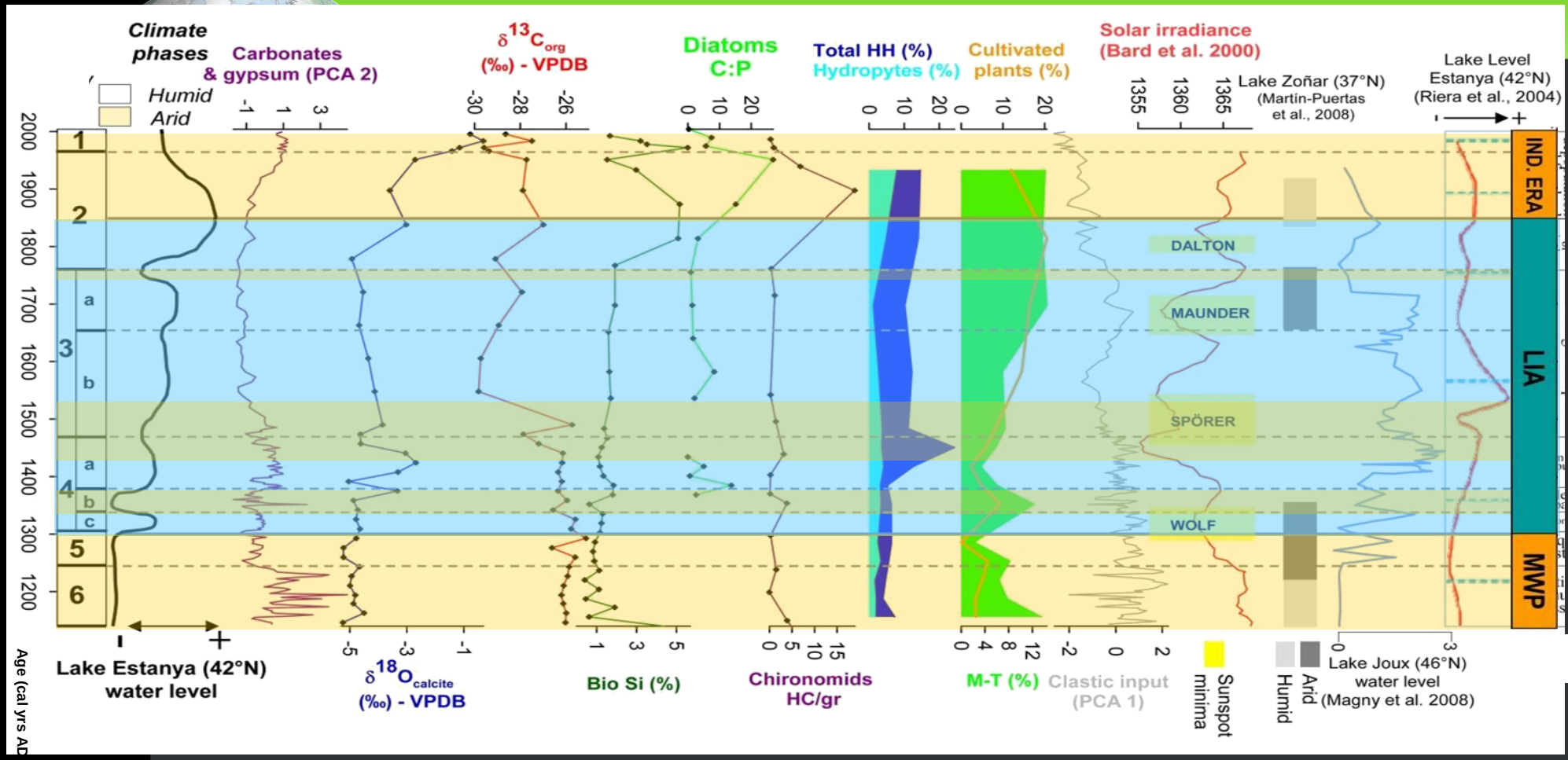
Introduction & Location

The Pyrenees: Estanya Lake

Morellón et al.,(2010)

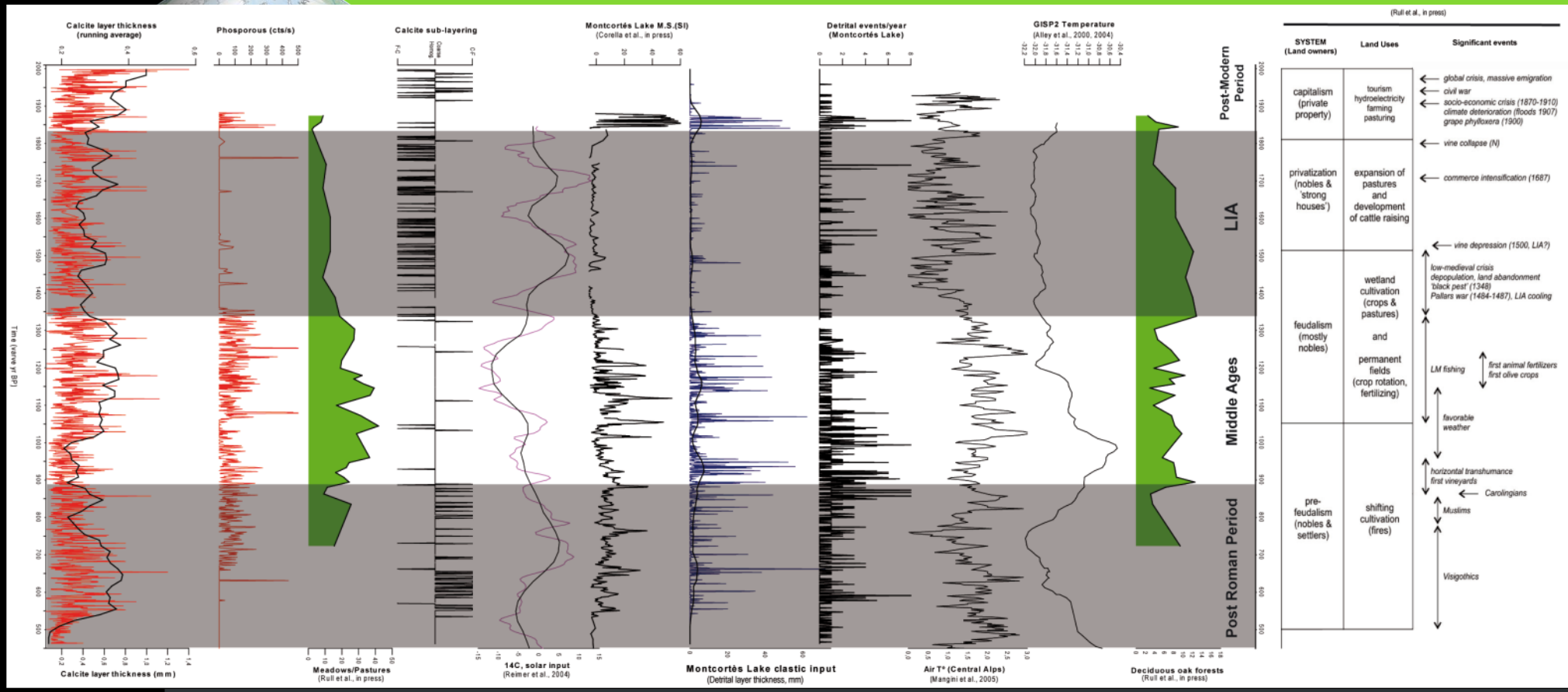


- Some dry phases during Roman times
- Arid MCA
- Humid LIA but with several phases

Introduction & Location

The Pyrenees: Montcortès Lake

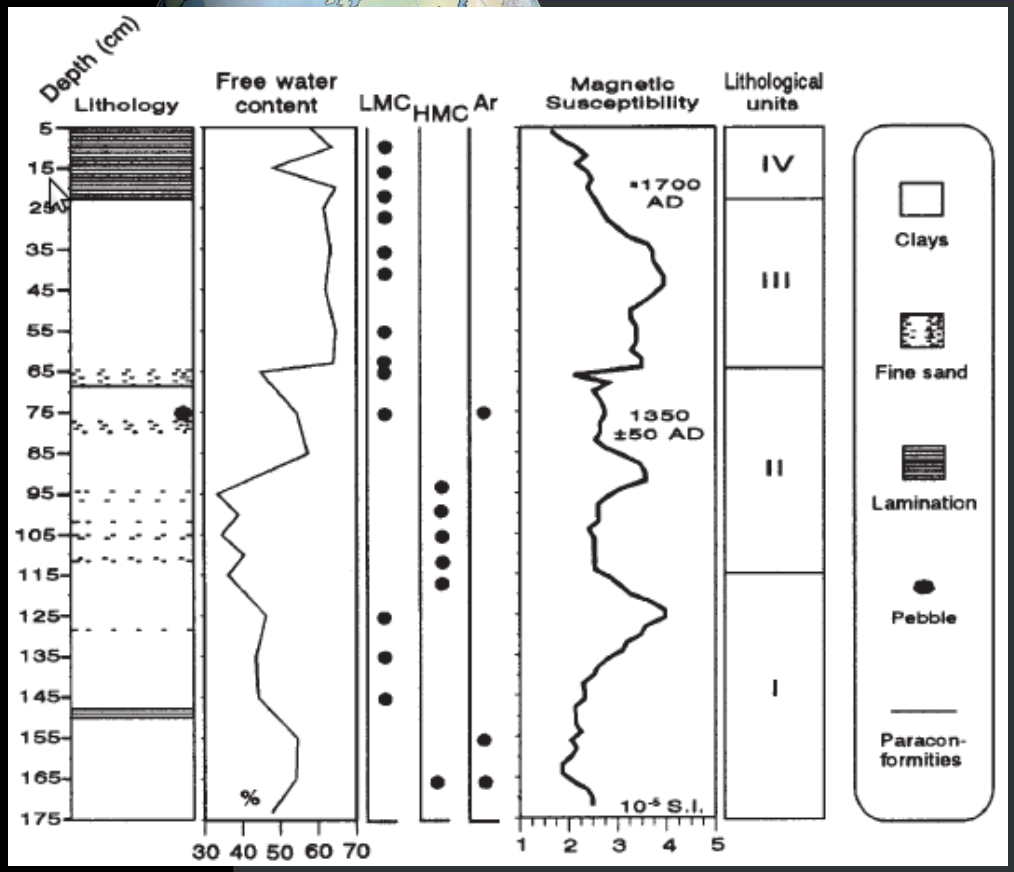
Corella et al. (S12-P02)



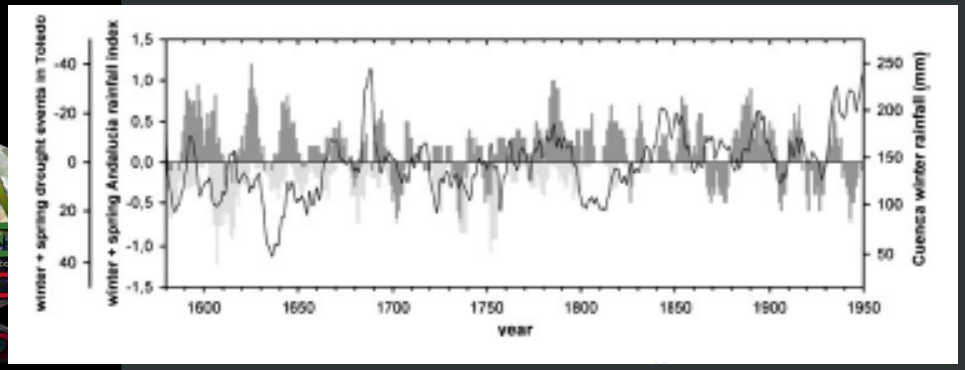
- A varved record for the last 1.5 ka!
- Arid MCA
- Cold (and humid) LIA

The Iberian Range: La Cruz

Julià et al., (1998), Romero-Viana, 2010)



- 1.75 m long core:
  - A varved record since the LIA
  - Arid MWA
  - Cold (and humid) LIA

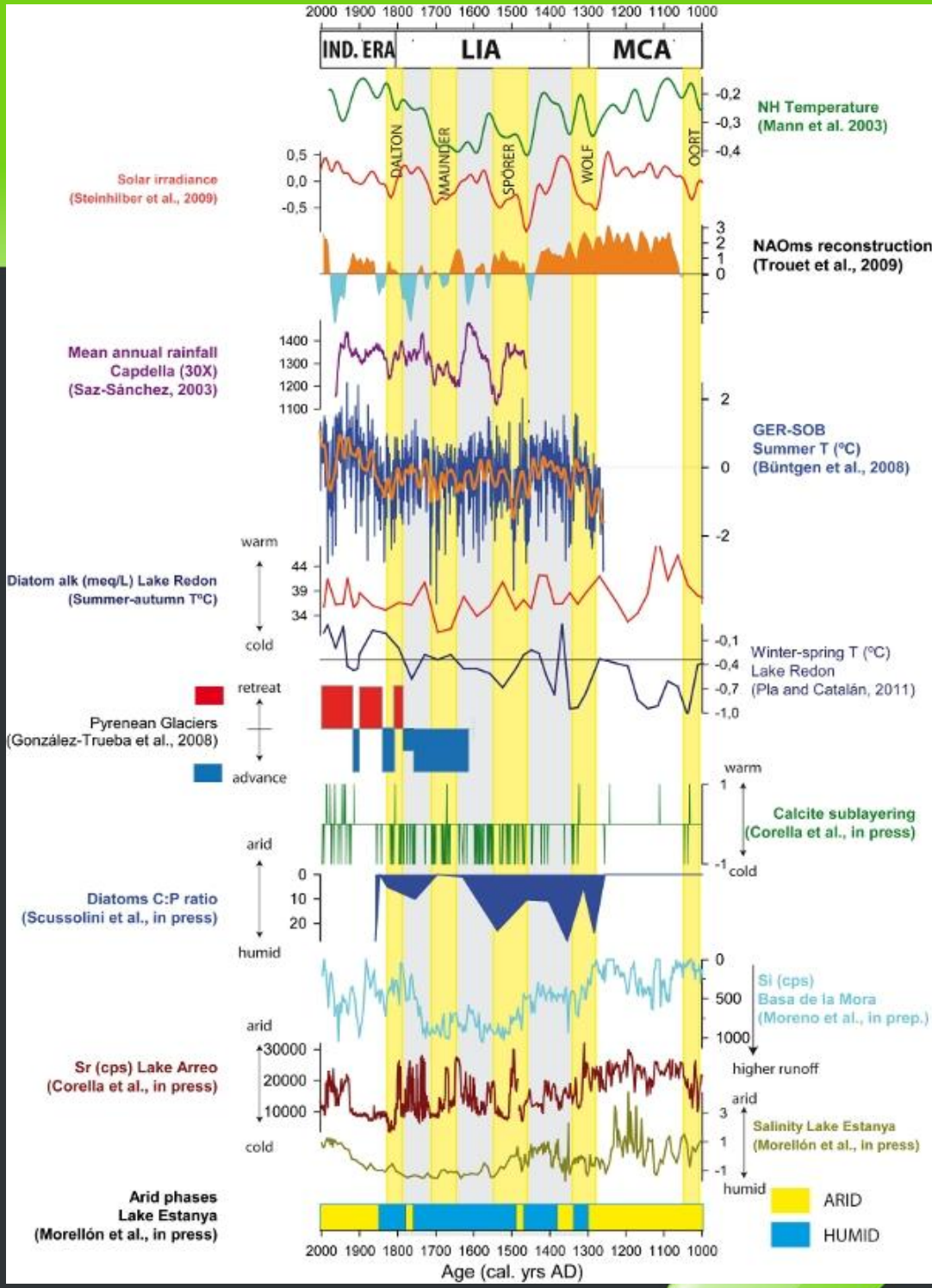


Reconstructed precipitation for the last 400 yr based on calcite laminae thickness

Last 2 ka

- The IRHP (2600-1600 yr BP) is the most humid period in the last 3500 yr (Zoñar lake) but not so much in northern Spain
- The MCA (IX- XV centuries): a relatively arid period in all records
- The LIA (1300-1850 yr AD) relatively wetter

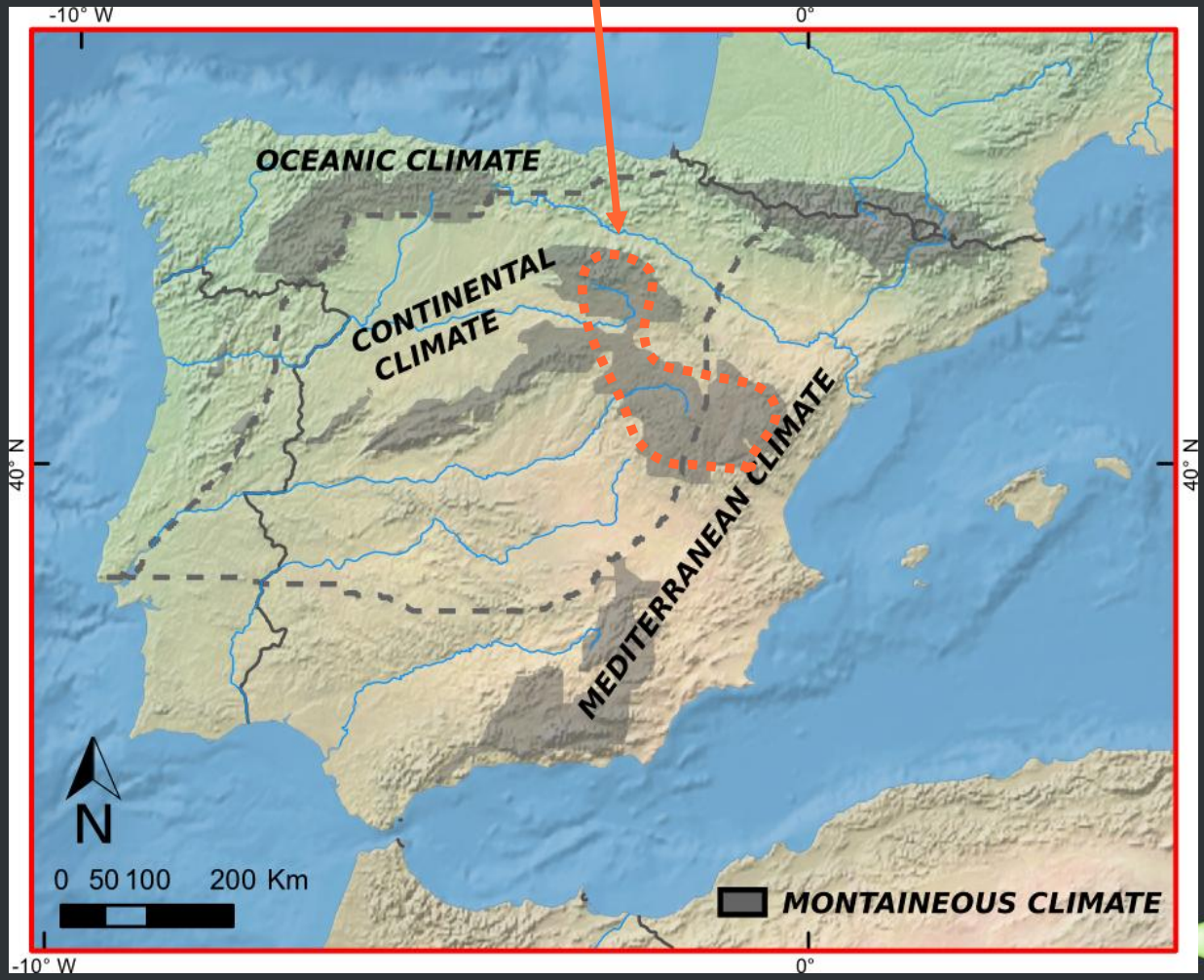
- **Regional (latitudinal) variability?**
- **Higher resolution (varves?)**



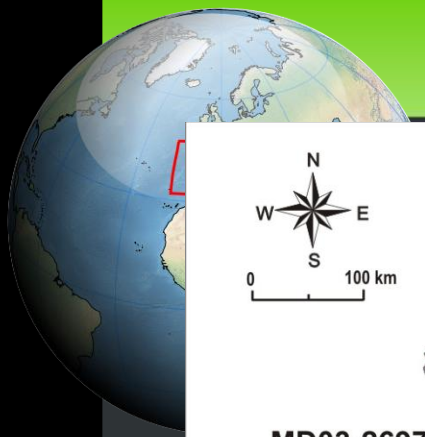
(Morellón et al., in press)

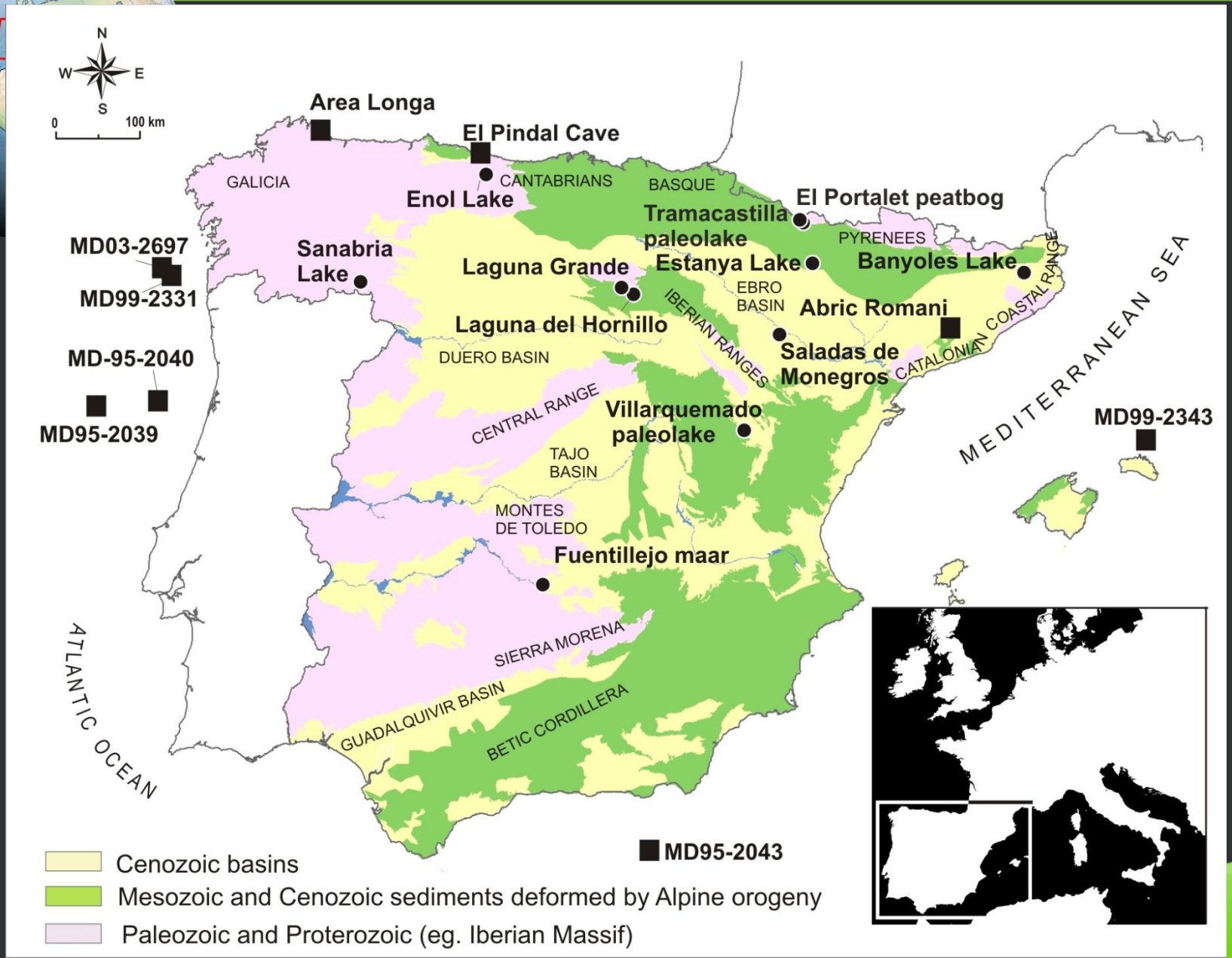
In search of varved sediments…

-Do Iberian karstic lake sequences contain high resolution paleoclimate information for the last millennia?..



The Iberian Peninsula : geology





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Large carbonate areas afected by endo- and exokarstic processes…

… developing

-travertine-damned lakes

-circular funnel-shaped depressions

-These systems are sensitive to climate changes and their sedimentary records are a good approach to study the fluctuations of the hydrological cycle

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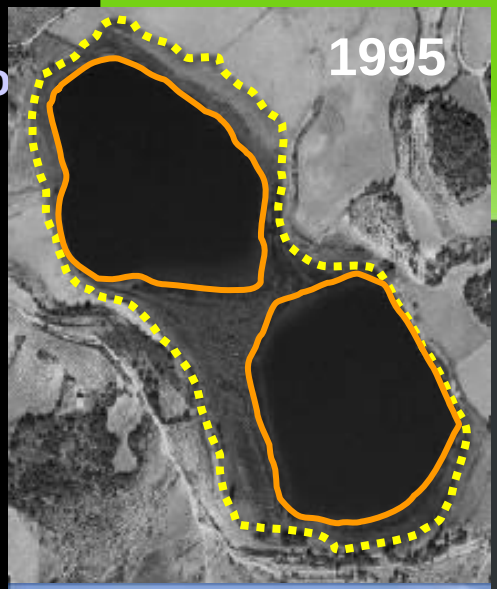
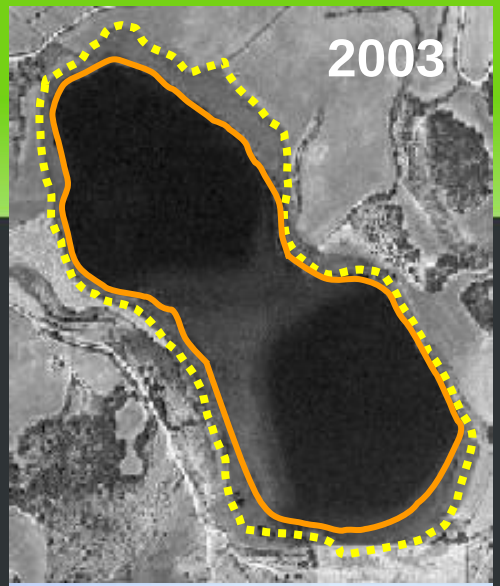
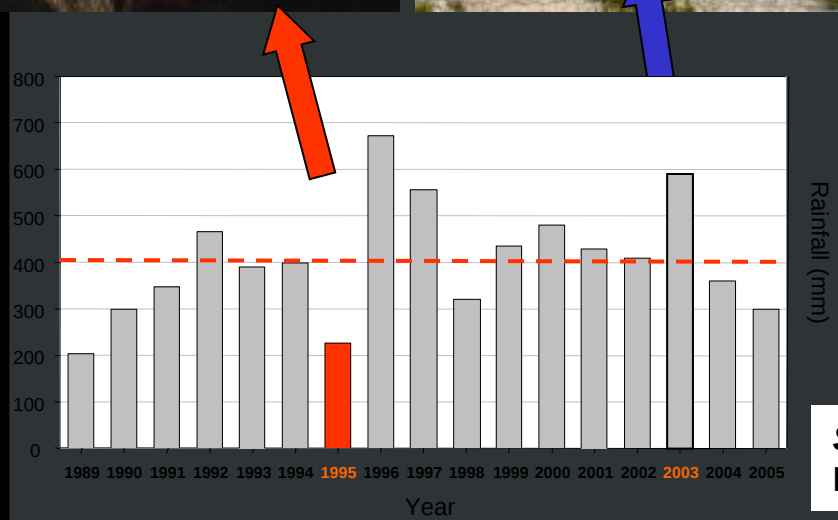
Estanya Lake (Pyrenees)







- **Lake hydrology:**

→Groundwater input *vs.* evaporation output

- **Evidences of relatively rapid response of water level to rainfall variability:**

  - ***Dry year* 1995 → isolation of NW and SE sub-basins**
  - ***Humid year* 2003 → sill separating the 2 sub-basins submerged, at 2-3 m water depth**

***Source:* Ebro Basin Watershed Authority (CHE) Morellón et al. 2009.**

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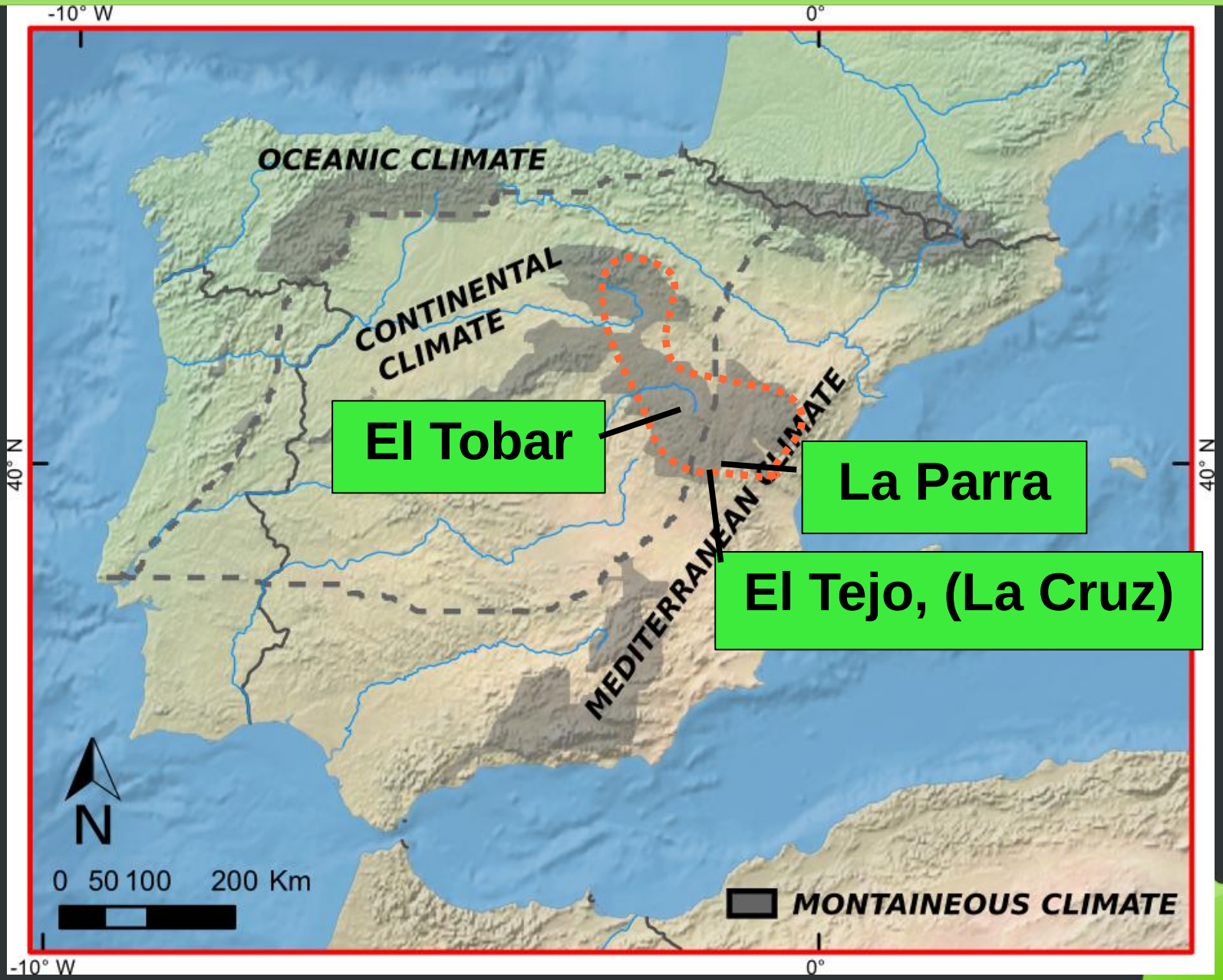
Lakes in the Iberian Range



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La Parra Lake

Located on a doline system developed on Cretaceous carbonatic formations.

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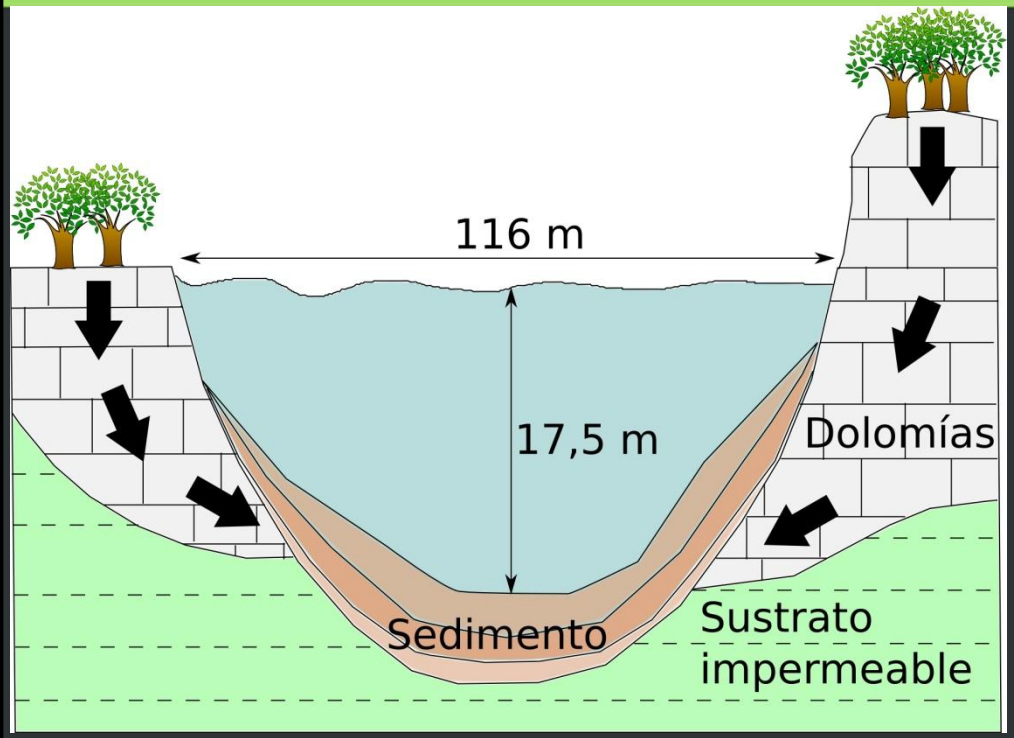
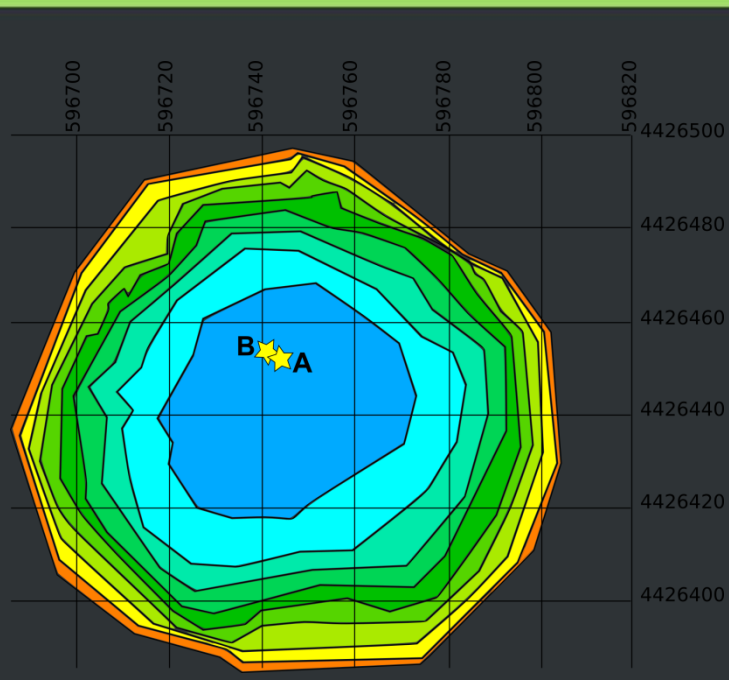
La Parra

The Lake





- **Inputs**: Groundwater and runoff-water.
- **Outputs**: Irrigation wells

The lake is Holomictic

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The Cores

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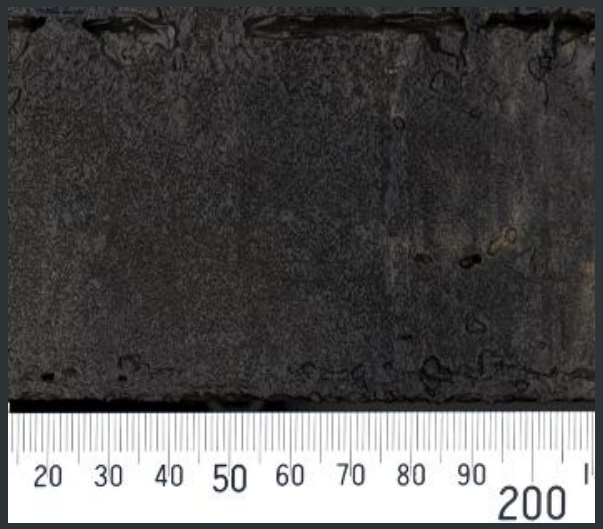
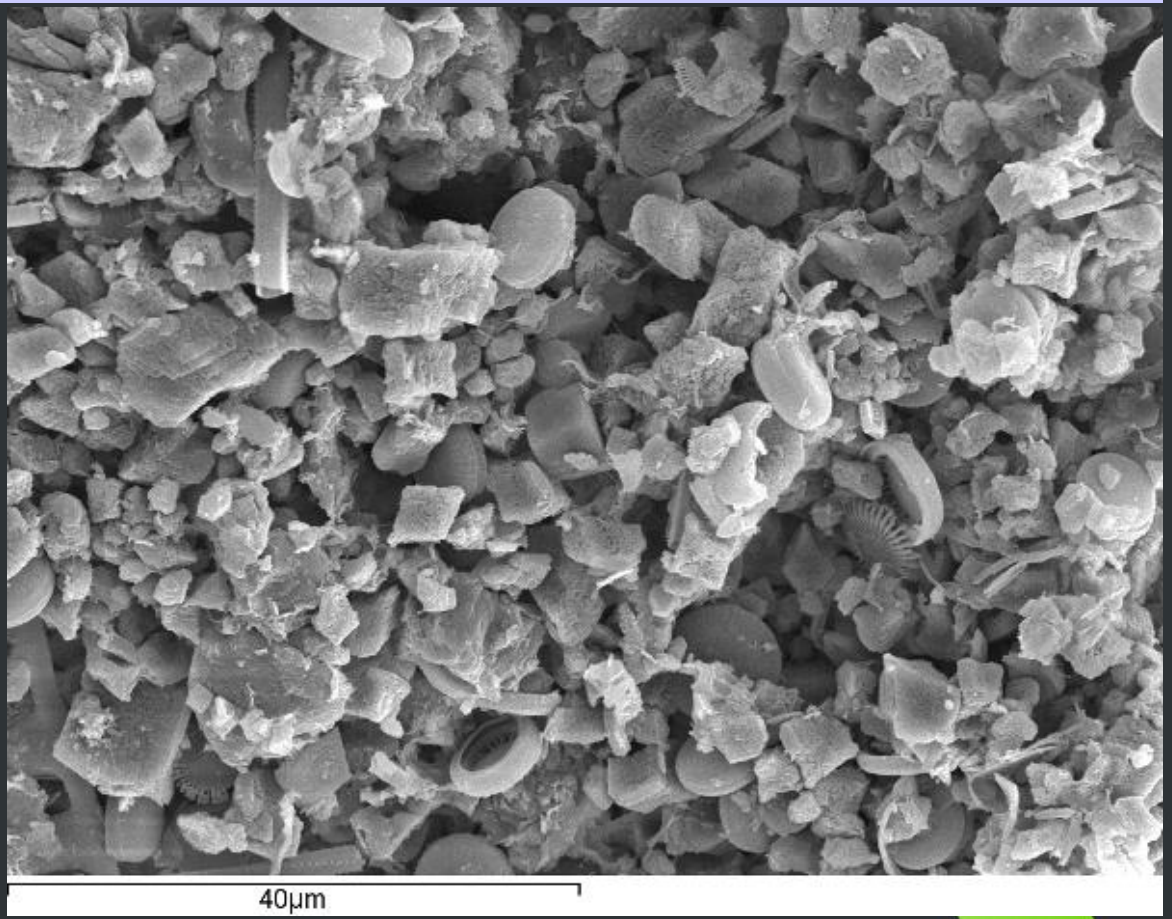
Sedimentology

Detrital Facies		Description
A	***Grey fine silts***	Massive, in beds of 10-25 cm and diffuse contacts





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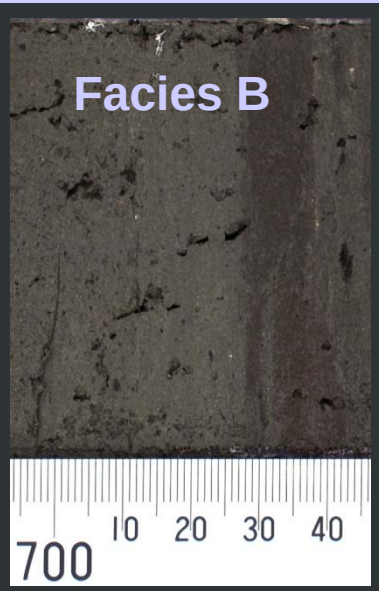
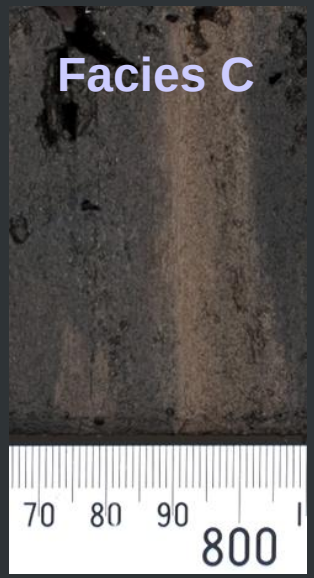
Sedimentology

	Detrital Facies	Description
B	*Black fine silts*	Massive in isolated levels of 2-5 cm with net boundaries

	Detrital Facies	Description
C	*Medium brown silts*	Layers of 5-20 cm with difusse boundaries.





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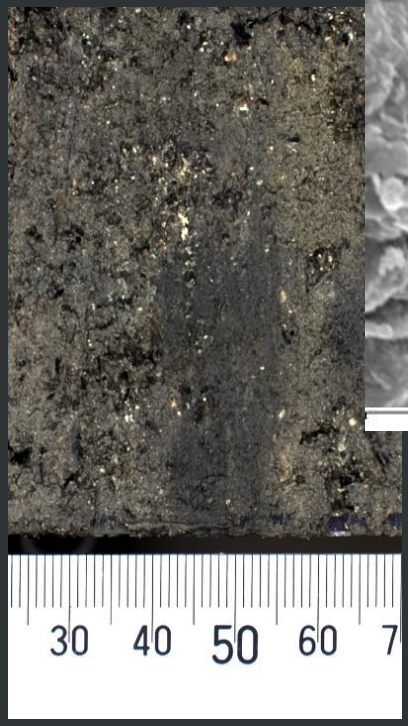
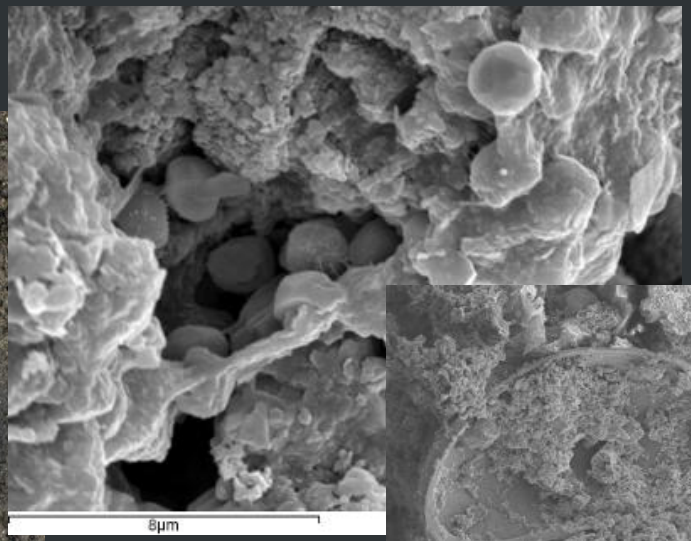
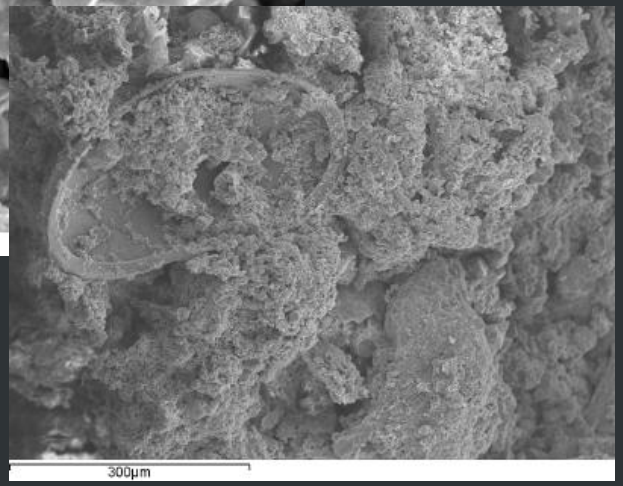
Sedimentology

Detrital Facies		Description
D,E	***Coarse dark & clear grey silts***	Massive levels of 5-10 cm with irregular basal boundaries and abundant OM fragments







Facies D

Facies E

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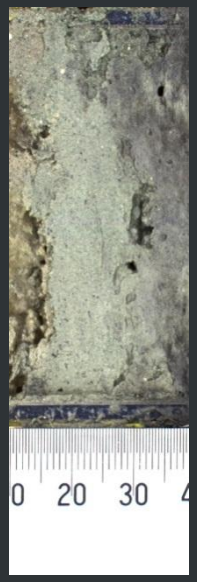
Sedimentology

	Detrital Facies	Description
F	***Very fine green sands***	Massive, forming isolated levels of 3-4 cm in a green silty matrix
G	***Medium brown sands***	Massive, in levels of 2-10 cm with irregular boundaries with a silty fine-medium matrix
H	***Coarse brown sands***	Massive, with angulous carbonatic pebbles in a level of 10 cm with very irregular boundaries

Facies F



Facies G

Facies H

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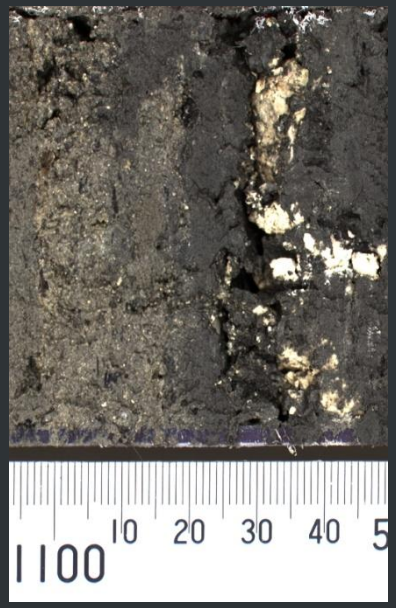
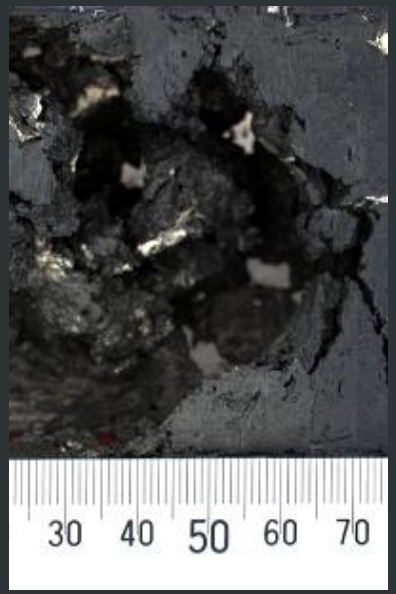
Sedimentology

	Detrital Facies	Description
I	***Fine brown gravels***	Massive, in a level of 2 cm with irregular boundaries. Pebbles are carbonatic.
J	***Medium brown gravels***	Massive, in a level of 30 cm with very irregular boundaries. Pebbles are carbonatic and with a silty matrix.

Facies I



Facies J



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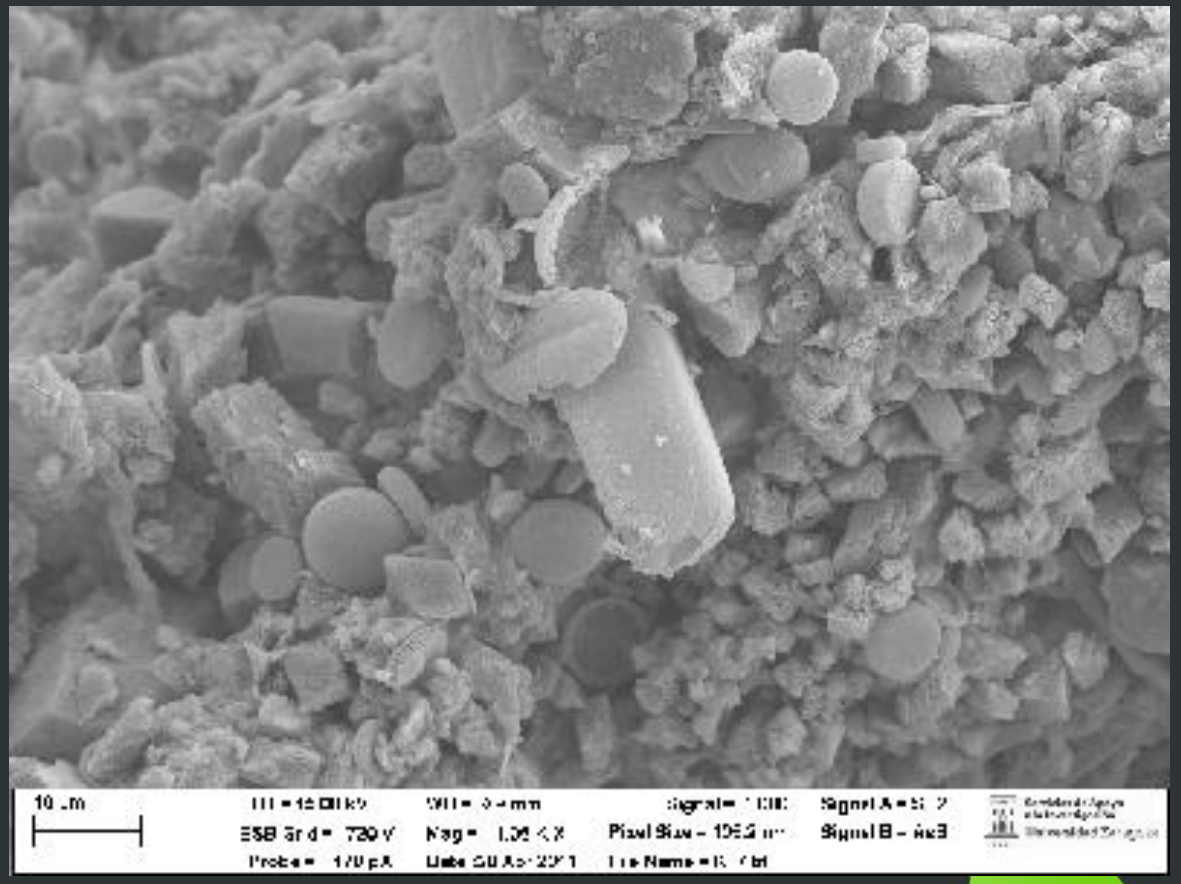
Sedimentology

	Detrital Facies	Description
K	*Fine laminated silts*	Sets of 5 cm with white calcitic and dark OM laminaes of 1 mm with net and regular boundaries



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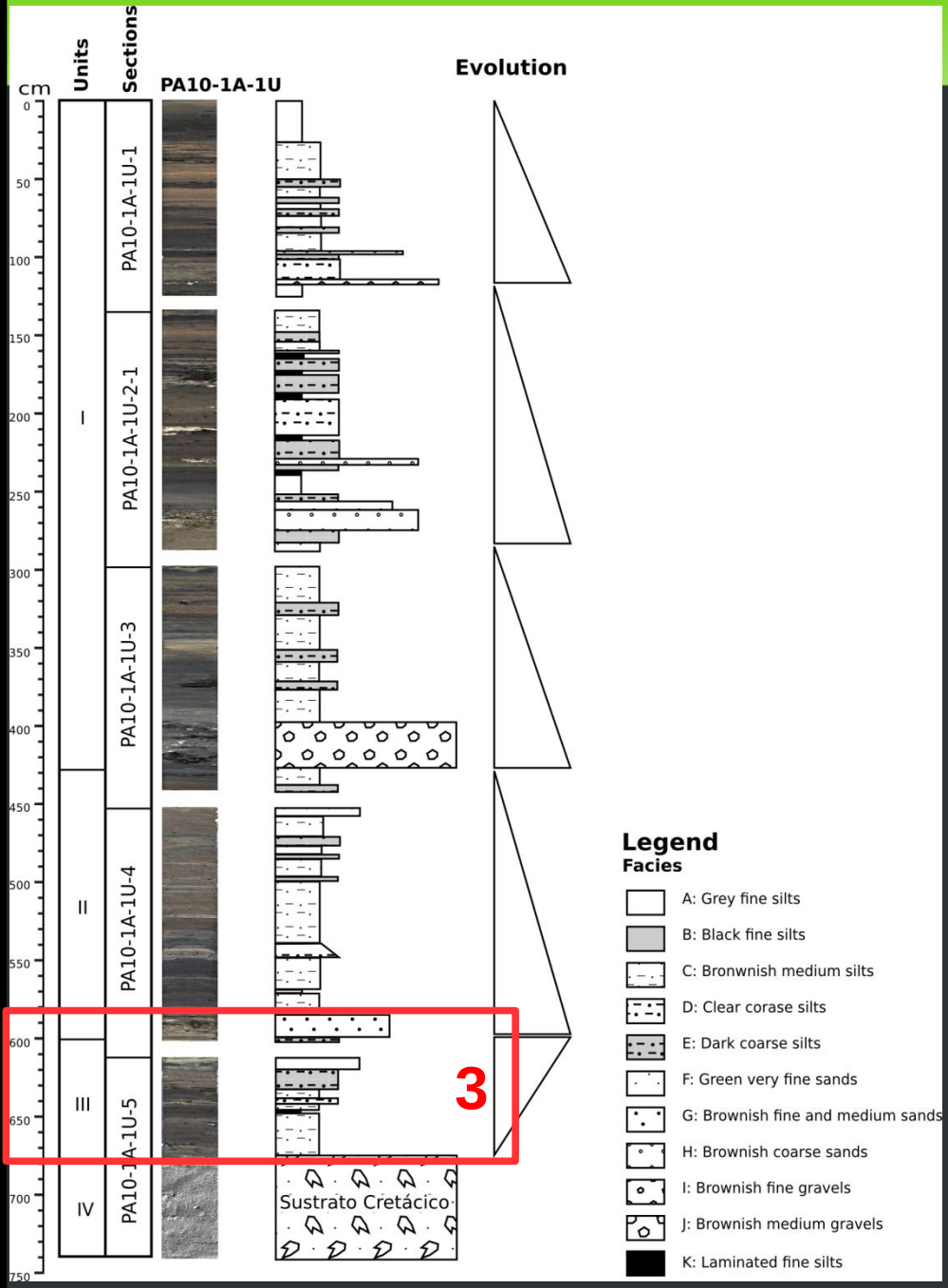
Unit III: 1st lacustrine deposits → Increase of water table



- Laminated facies grading to coarser silts:

- Rapid water table level changes;

- Littoral and shallower environment deposit .

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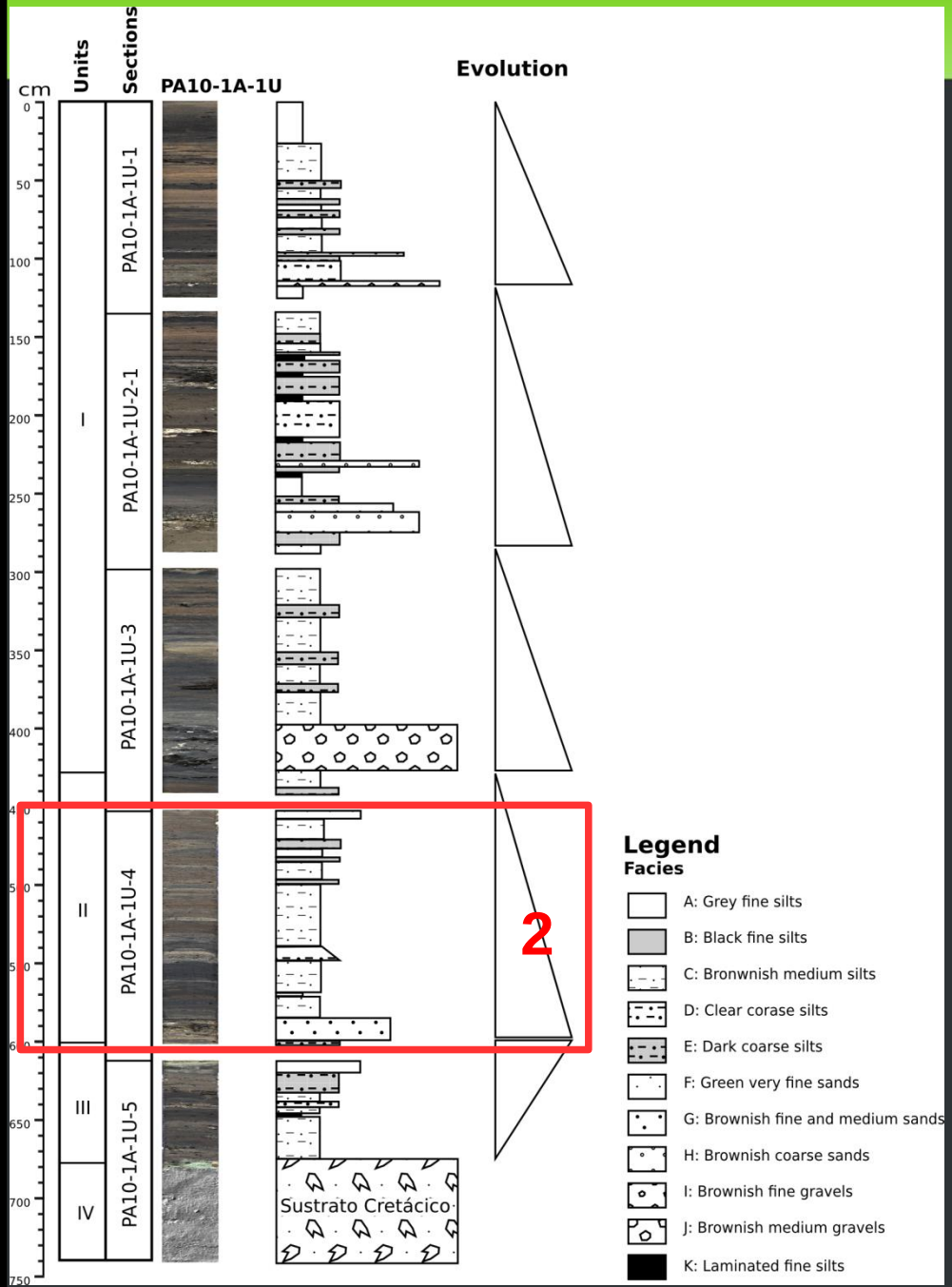
Unit II: Detrital fine facies



- Increase of fine siliciclastic inputs
- Implies:

- Higher lake levels

- Higher local anthropogenic impacts (erosion).

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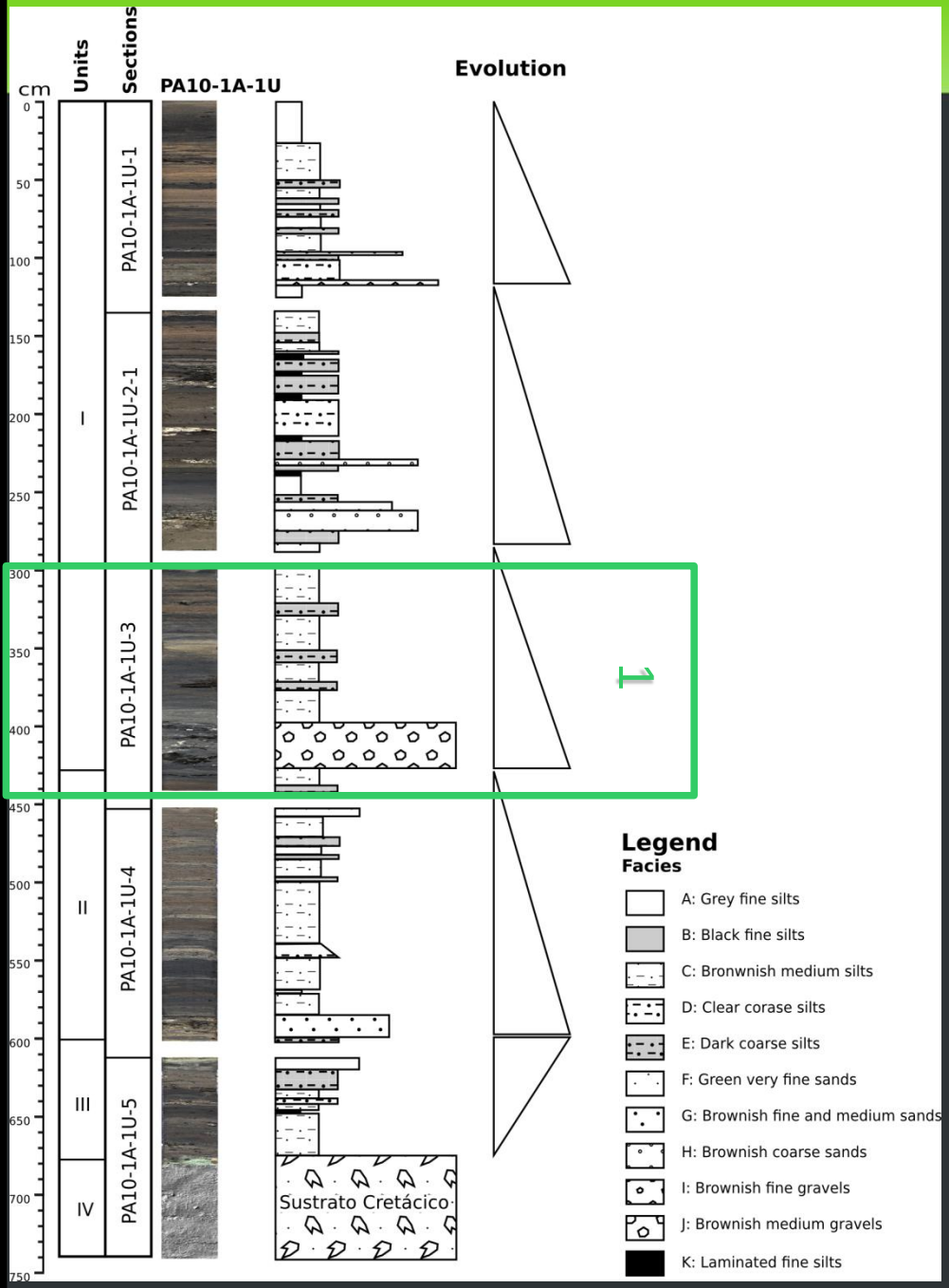
Bottom Unit I: Coarser facies deposition



- Coarser facies at the center of the lake:
- Implies shallower levels and an increase on proximal detrital inputs

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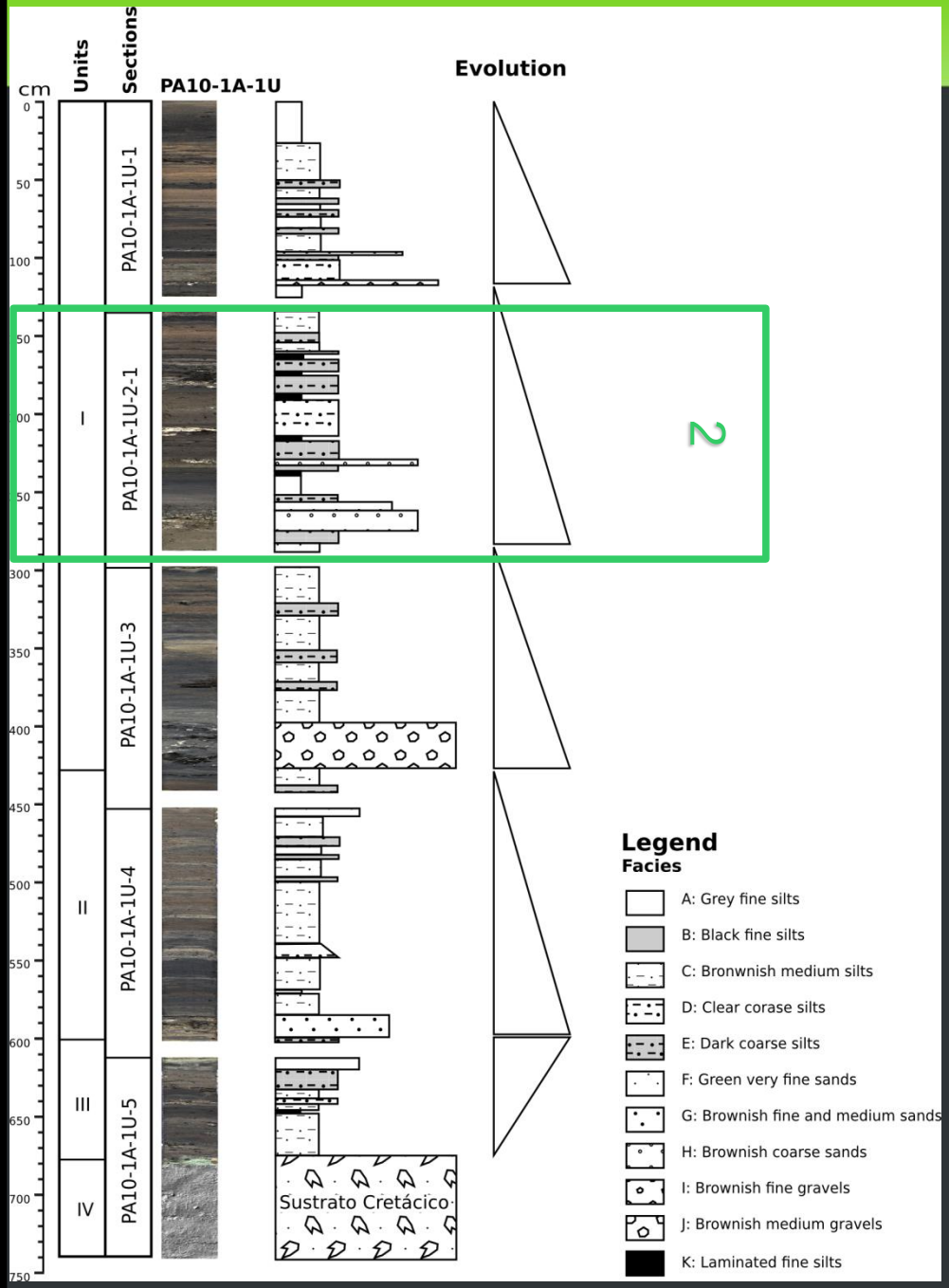
Medium Unit I: Fine and Laminated facies



- Higher lake levels.
- Laminated facies (more anoxic conditions at lake bottom)

(similar pattern than nearby La Cruz lake)

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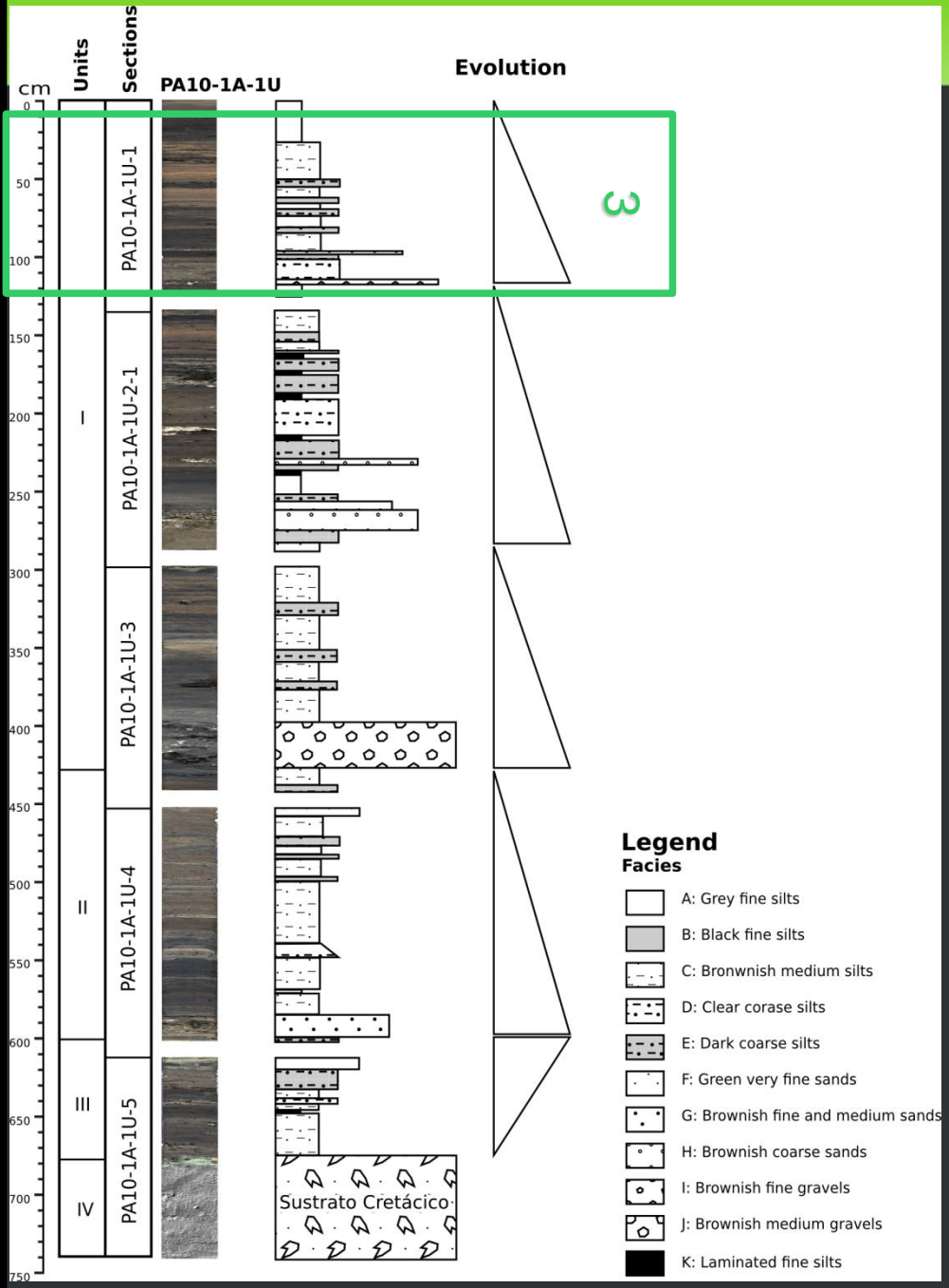
Top Unit I: Dominancy of fine massive silts



- Laminated facies disappear
- Relative drop of lake level during recent times

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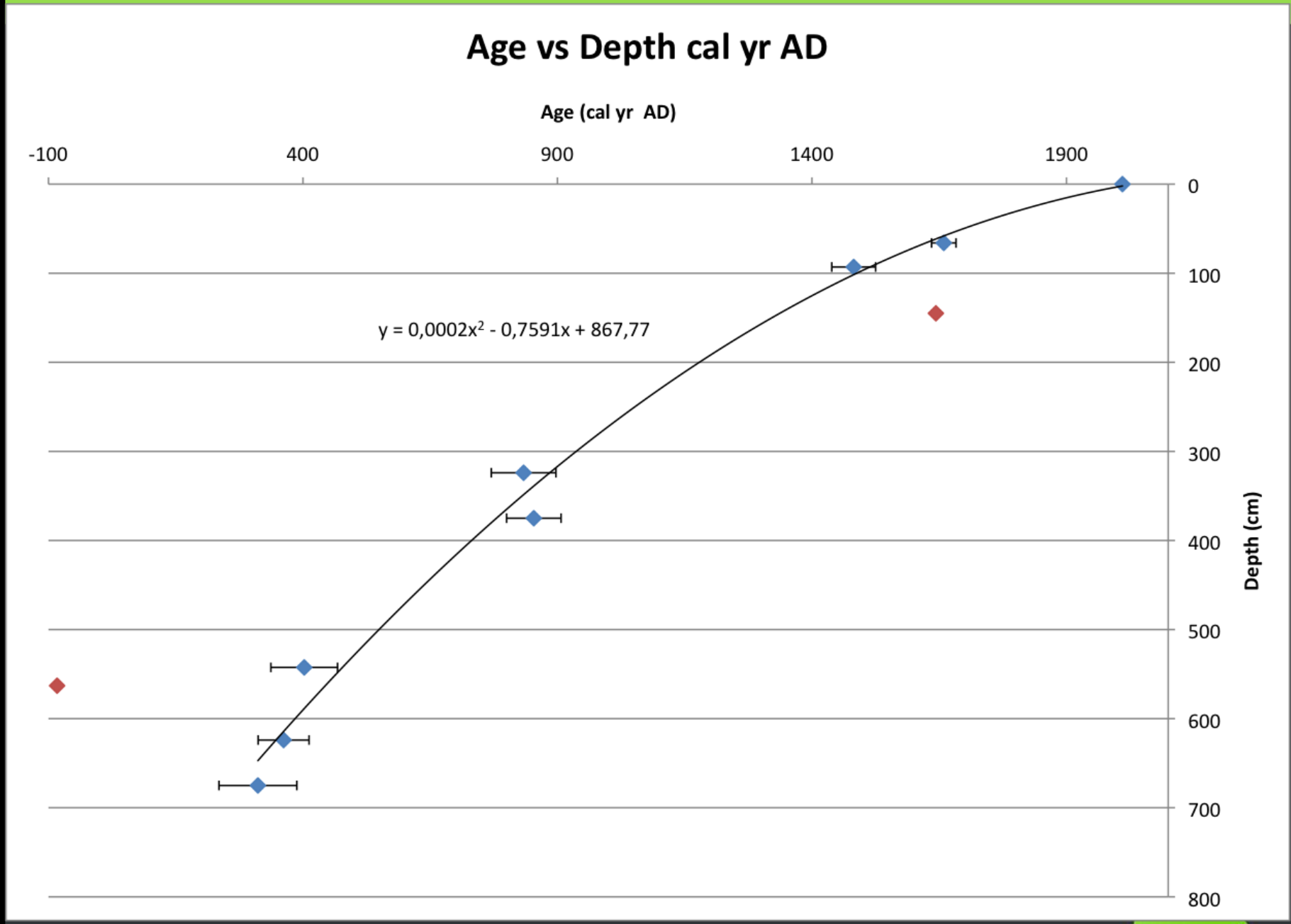
Age Model



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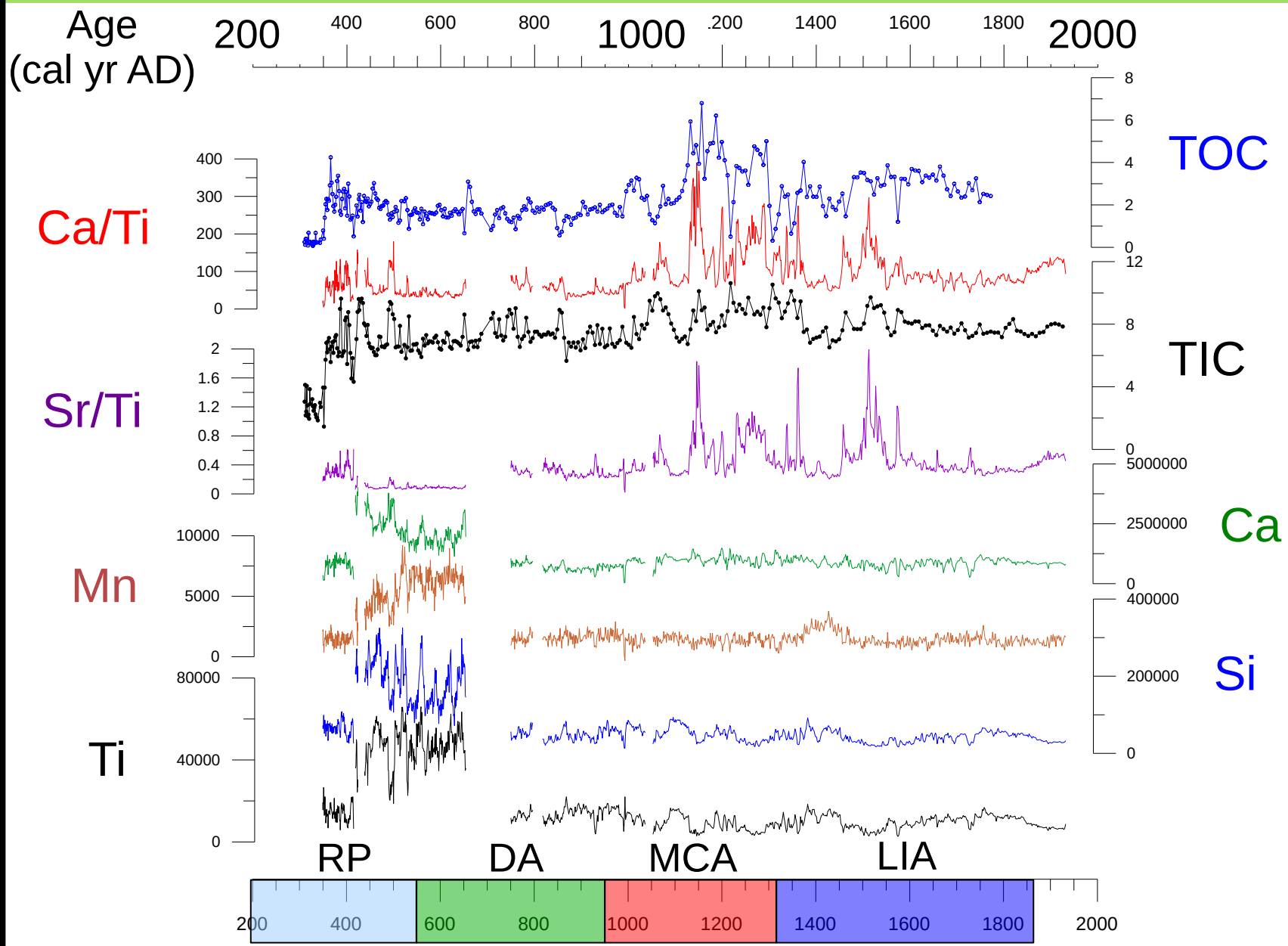
La Parra

Geochemical proxies



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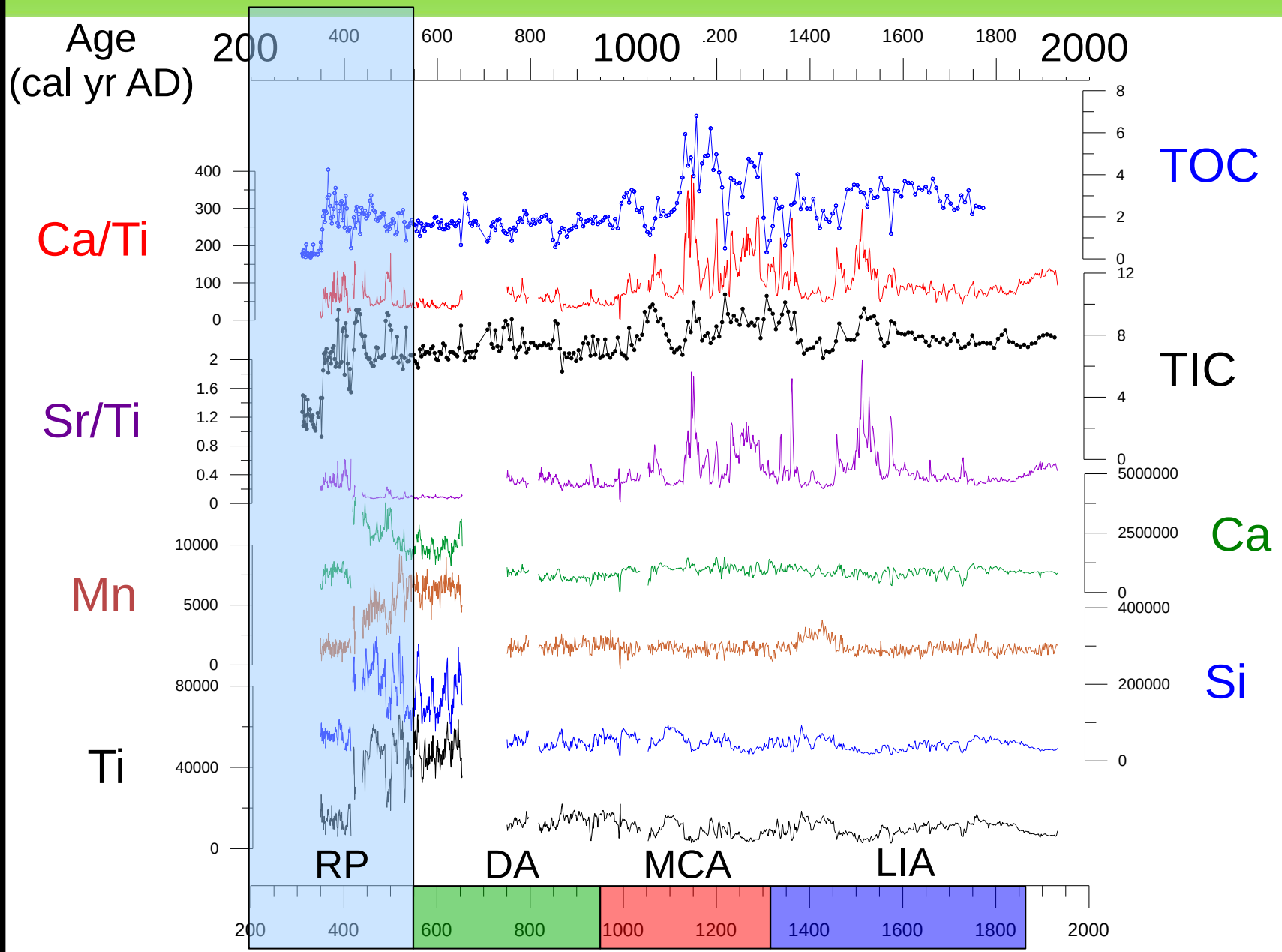
During the late IRHP (300-500 AD), occurs the onset of lacustrine sedimentation, with a rapid increase on detrital input (Ti, Si). Later a drop of water table (400 AD, more clastic facies) occurs.



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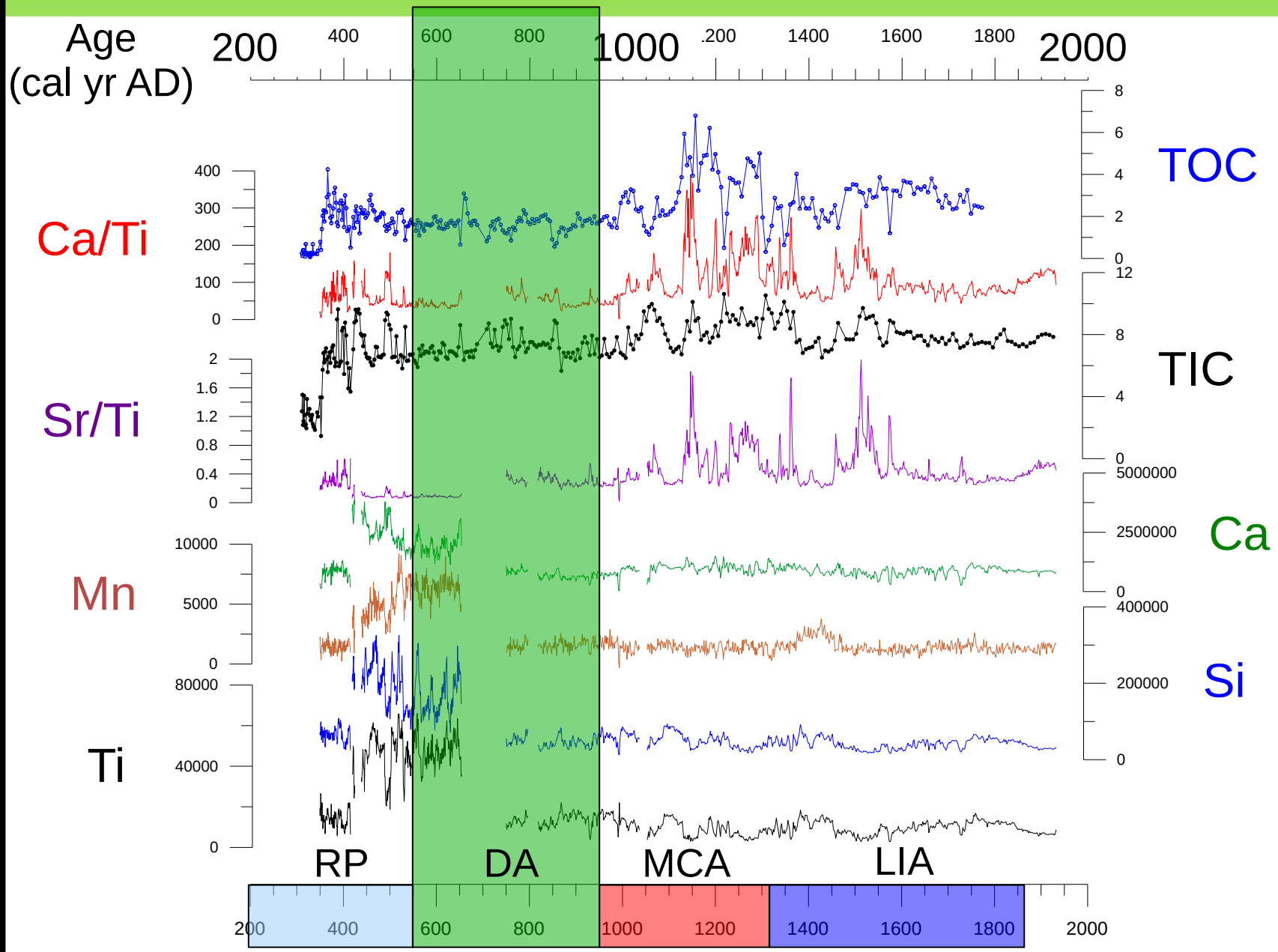
The DA (550-900 AD) start with higher clastic inputs (Ti, Si) to the lake and coarser facies occurs (lower lake levels). Later on, fine facies deposited (higher lake levels).



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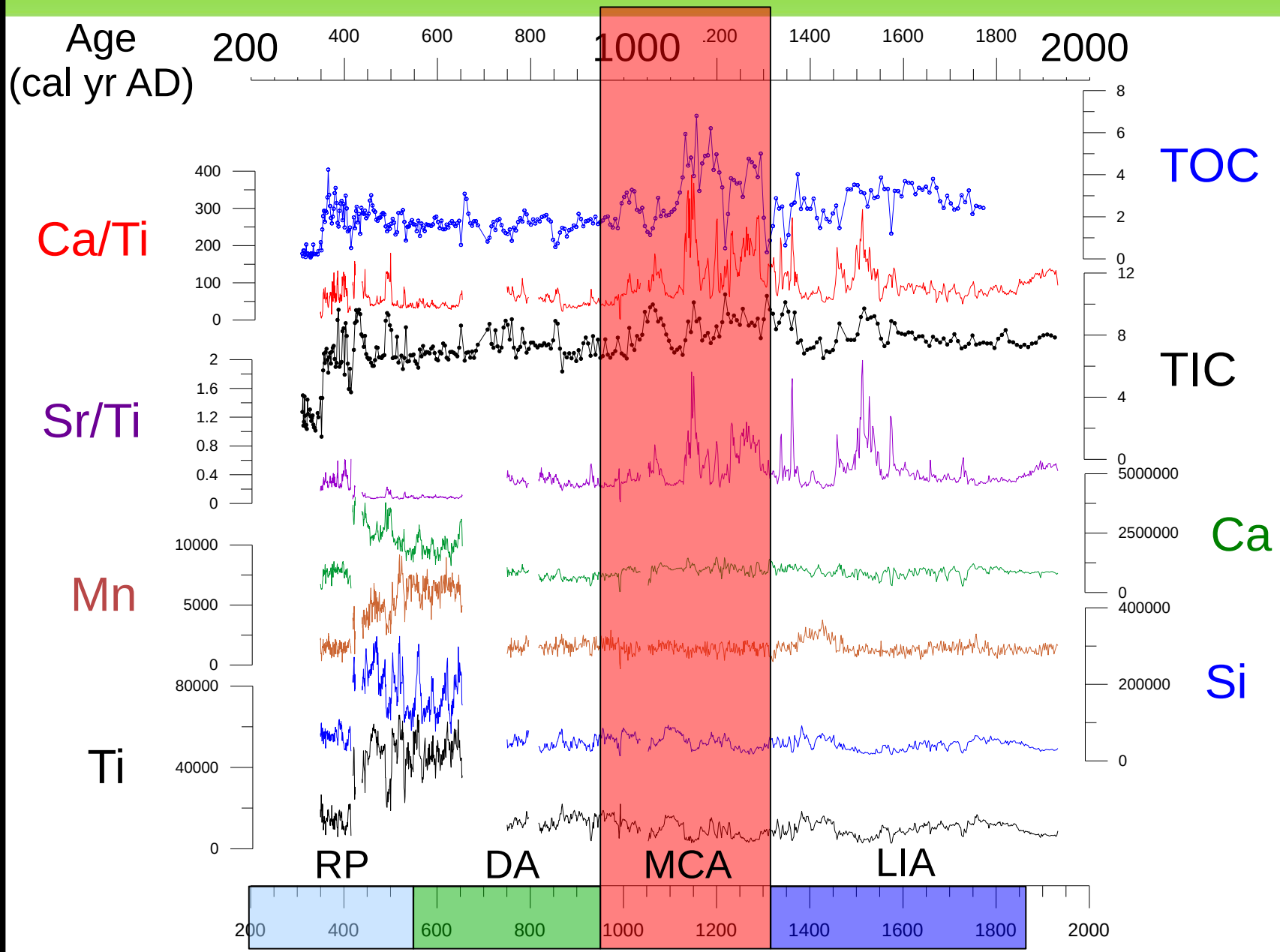
- During the onset of the MCA (900 AD) Ti content is low and coarser carbonate facies with detrital OM are deposited.
- High values of Sr/Ti, Ca/Ti and TOC suggest a shallower lacustrine environment..



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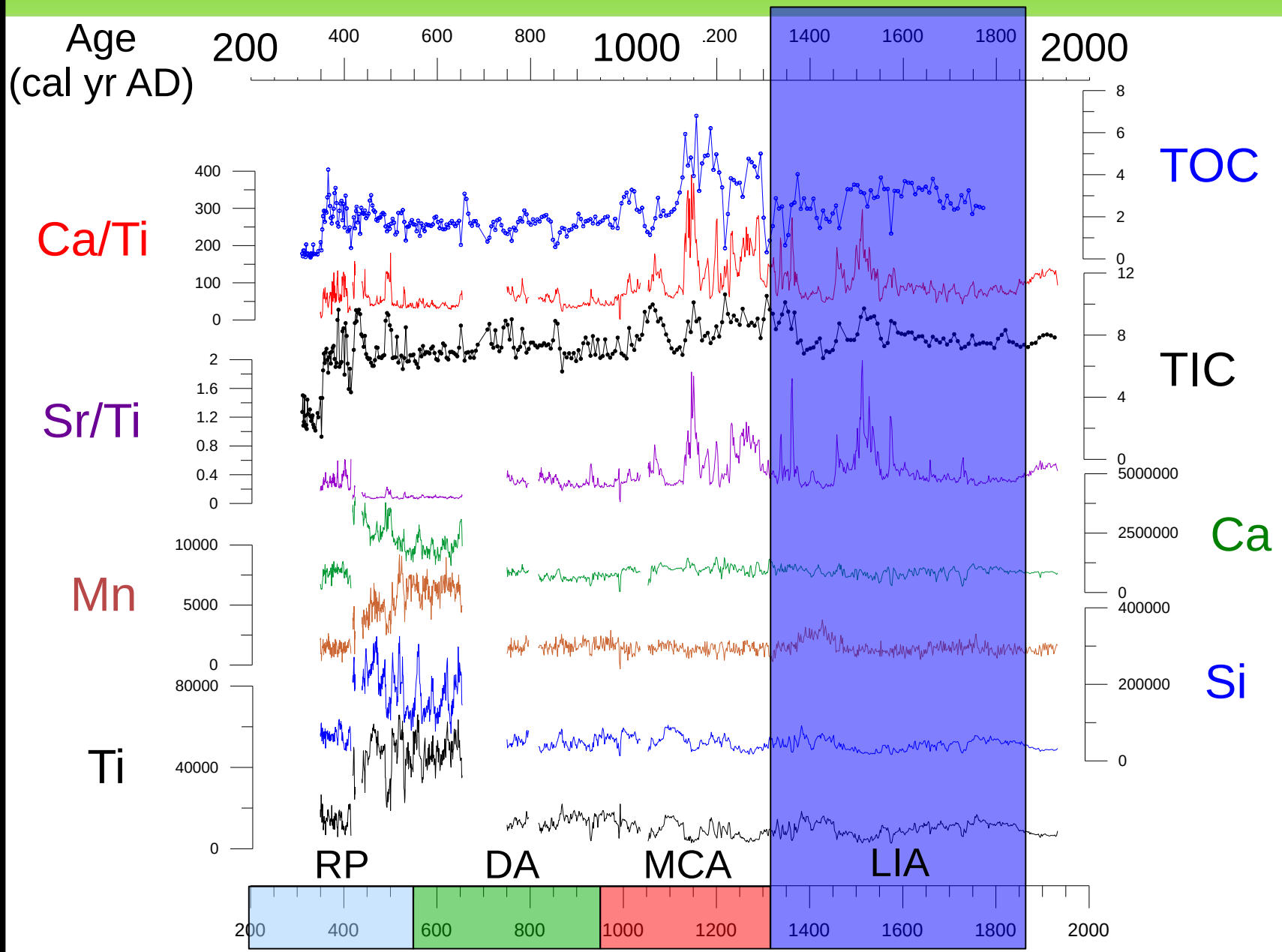
During the LIA (1300-1850), laminated anoxic facies occur. Sr/Ti, Ca/Ti and TIC have high values around 1500 AD → Higher lake levels (similar pattern La Cruz lake).



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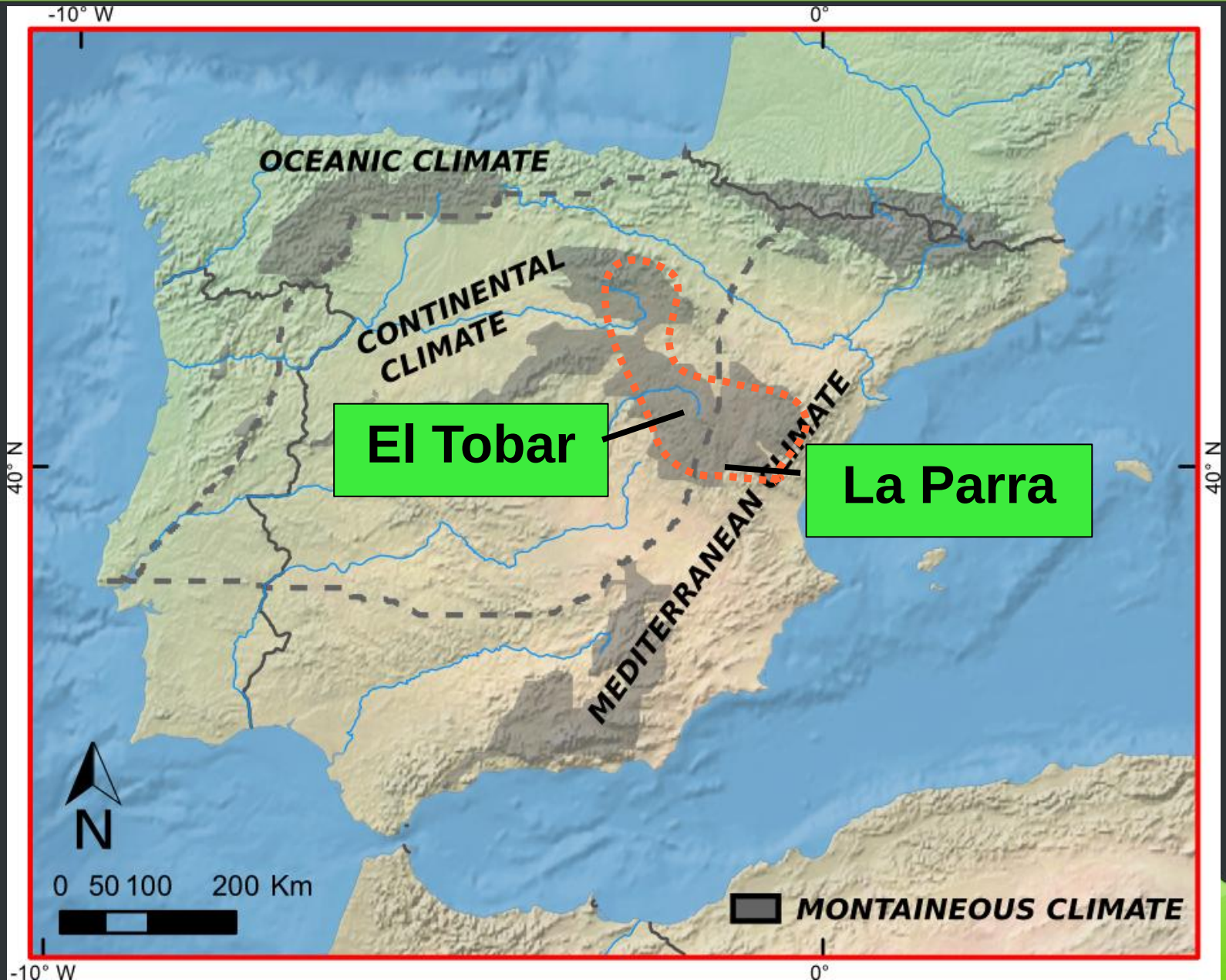
The Lakes



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MERCURY
MERCURY

El Tobar

The Lake

2 sub-basins:

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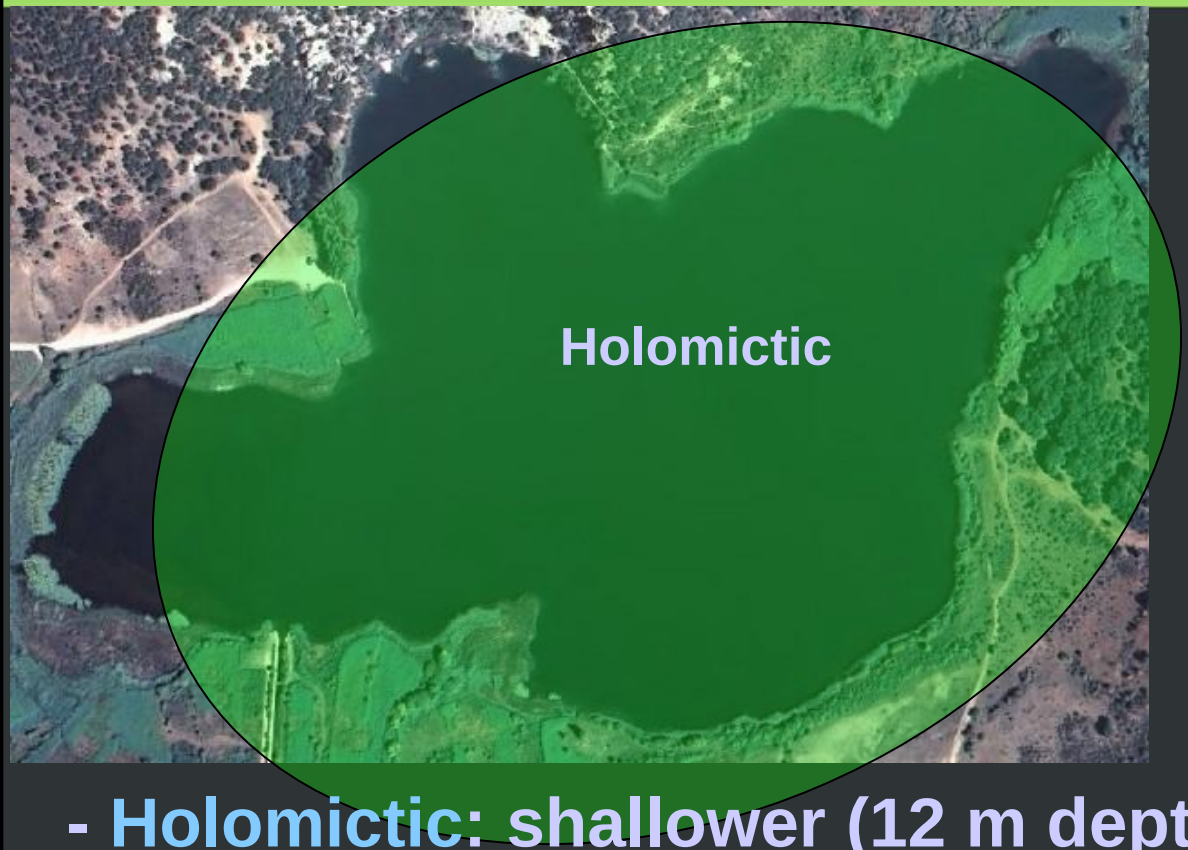
El Tobar

The Lake



2 sub-basins:

- Holomictic: shallower (12 m depth)

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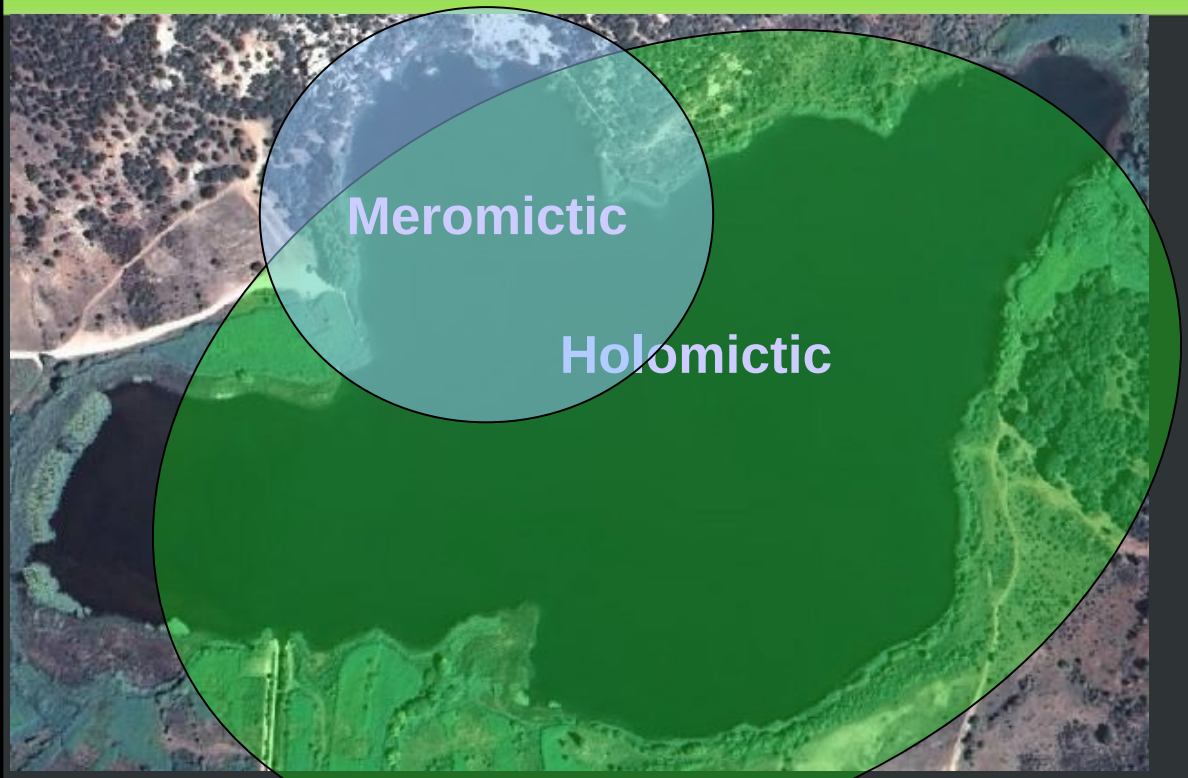
El Tobar

The Lake



2 sub-basins:

- **Holomictic: shallower (12 m depth)**

- **Meromictic: funnel-shaped (20 m) → Has a permanent saline anoxic monimolimnion below 12 m due to groundwater seepage.**

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El Tobar

Connection with nearby reservoir “La Tosca”

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El Tobar

The Lake

Fresh water springs

Connection with nearby reservoir “La Tosca”

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El Tobar

The Lake

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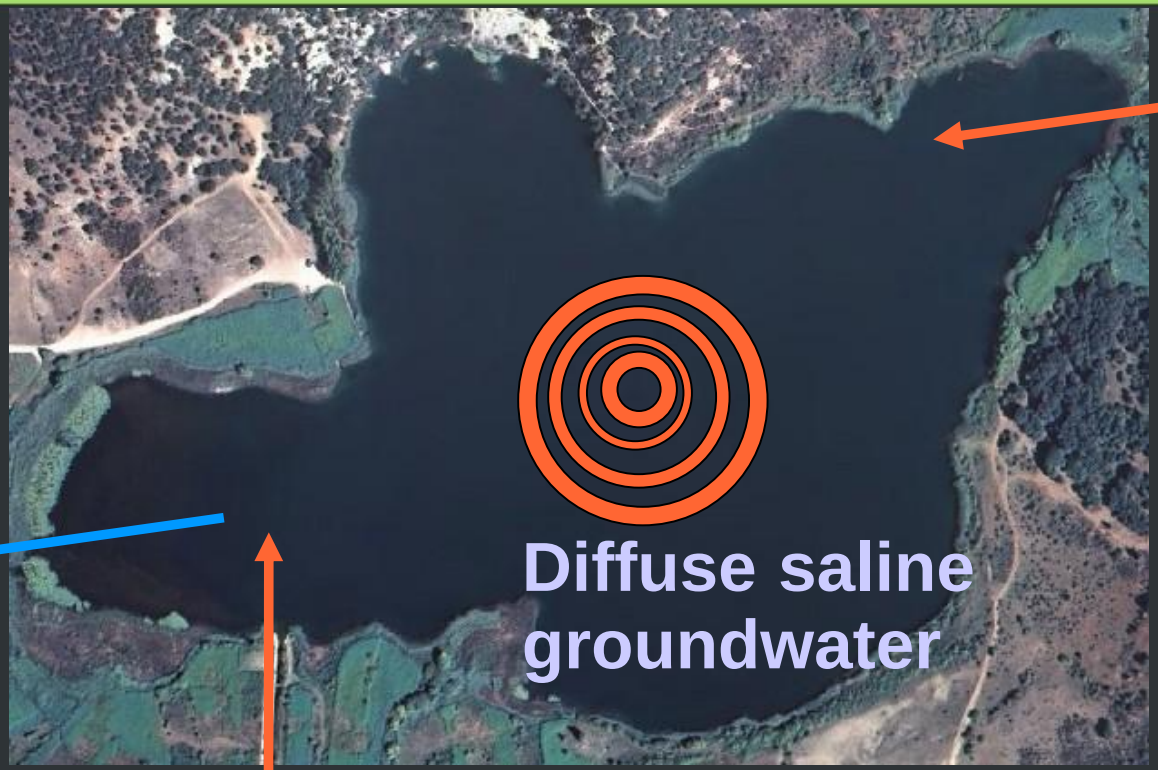
El Tobar

The Lake



Fresh water springs

Surface outlet

Diffuse saline groundwater

Connection with nearby reservoir “La Tosca”

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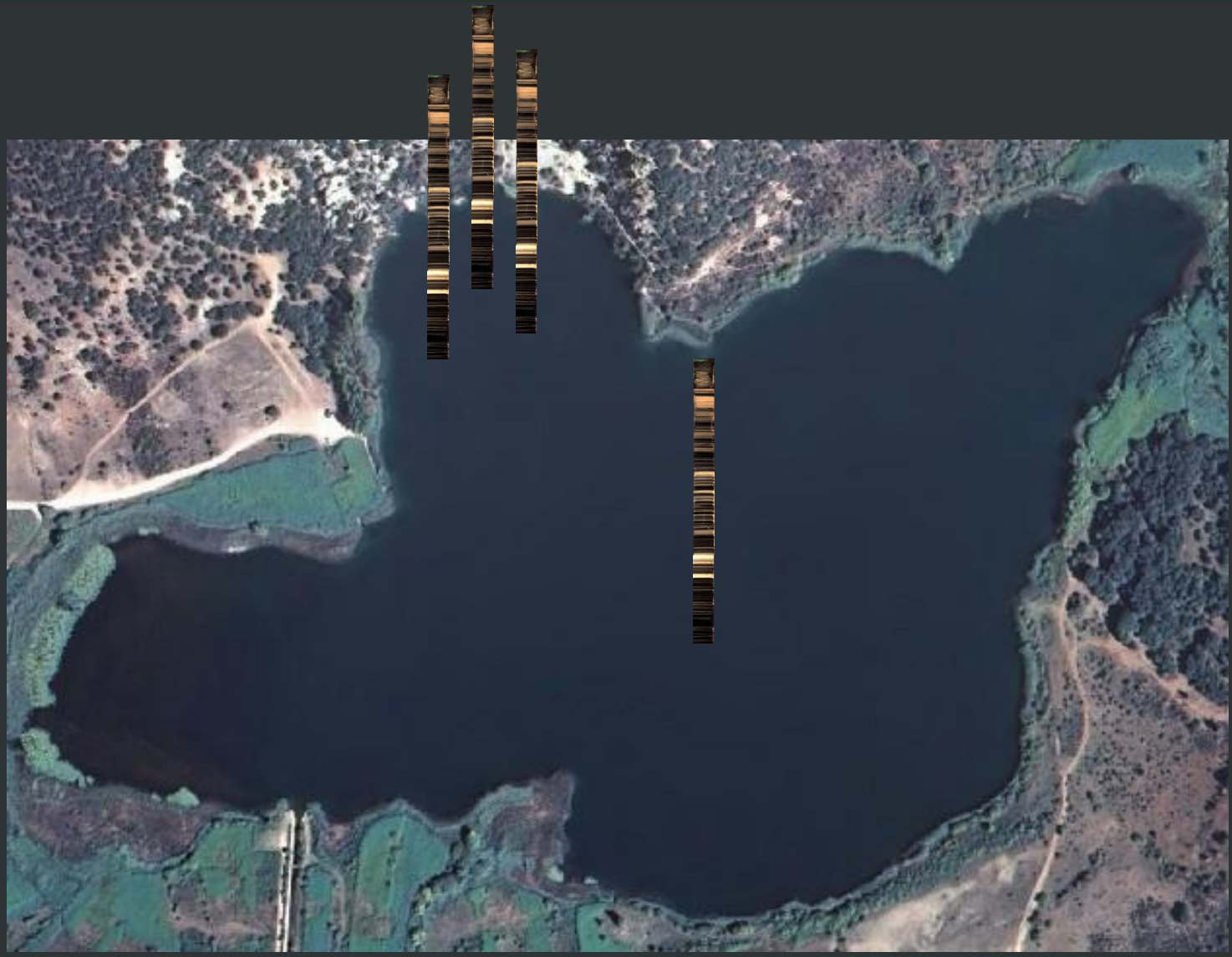
El Tobar

Cores



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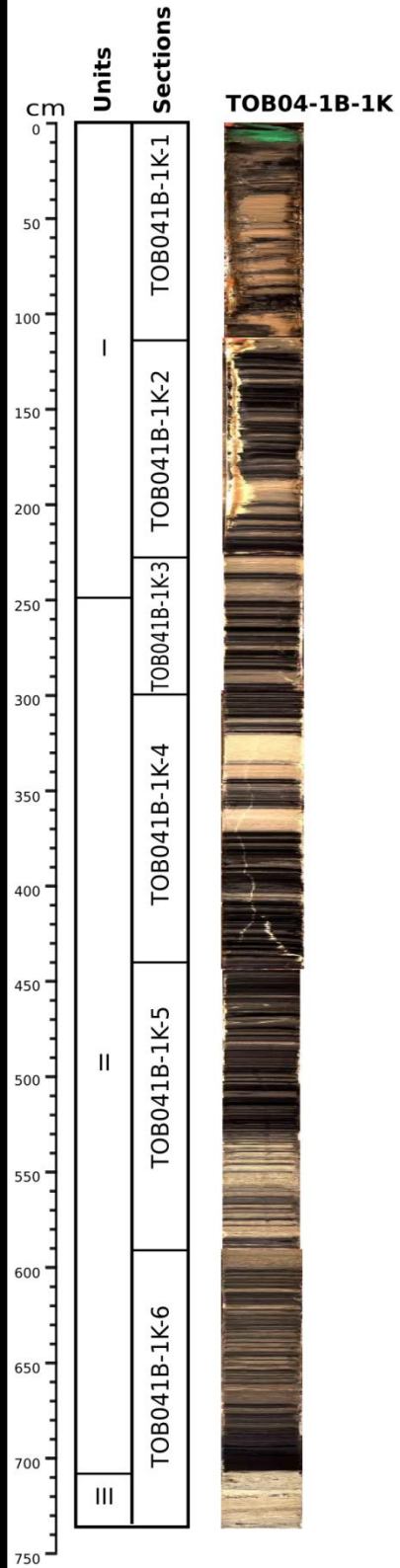

Sedimentology

6 main facies have been identified

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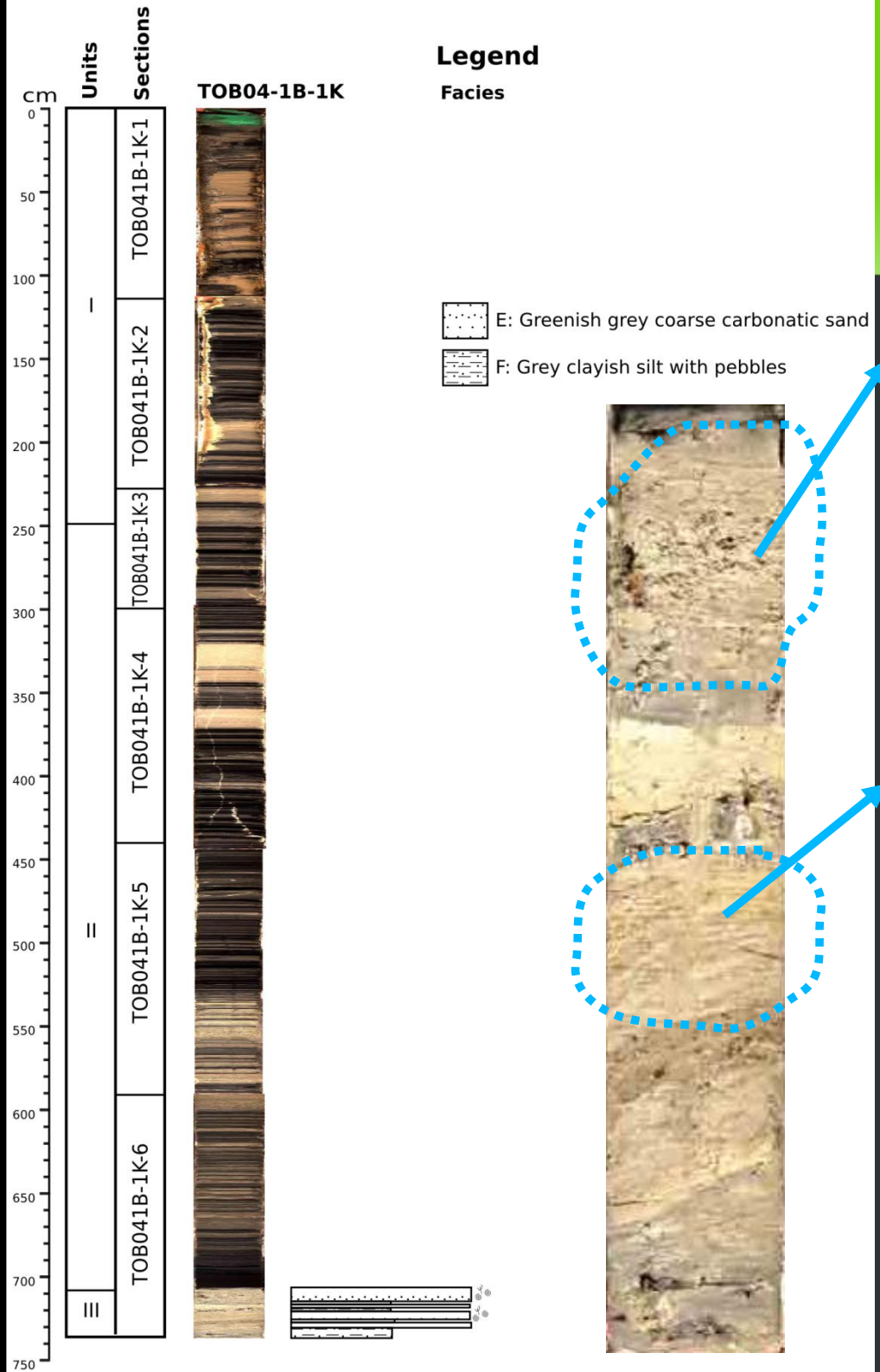

Sedimentology

Facies E: Greenish grey coarse carbonate-rich sand with plant and gastropod remains and diatoms.

Facies F: Grey clayish silt with pebbles.

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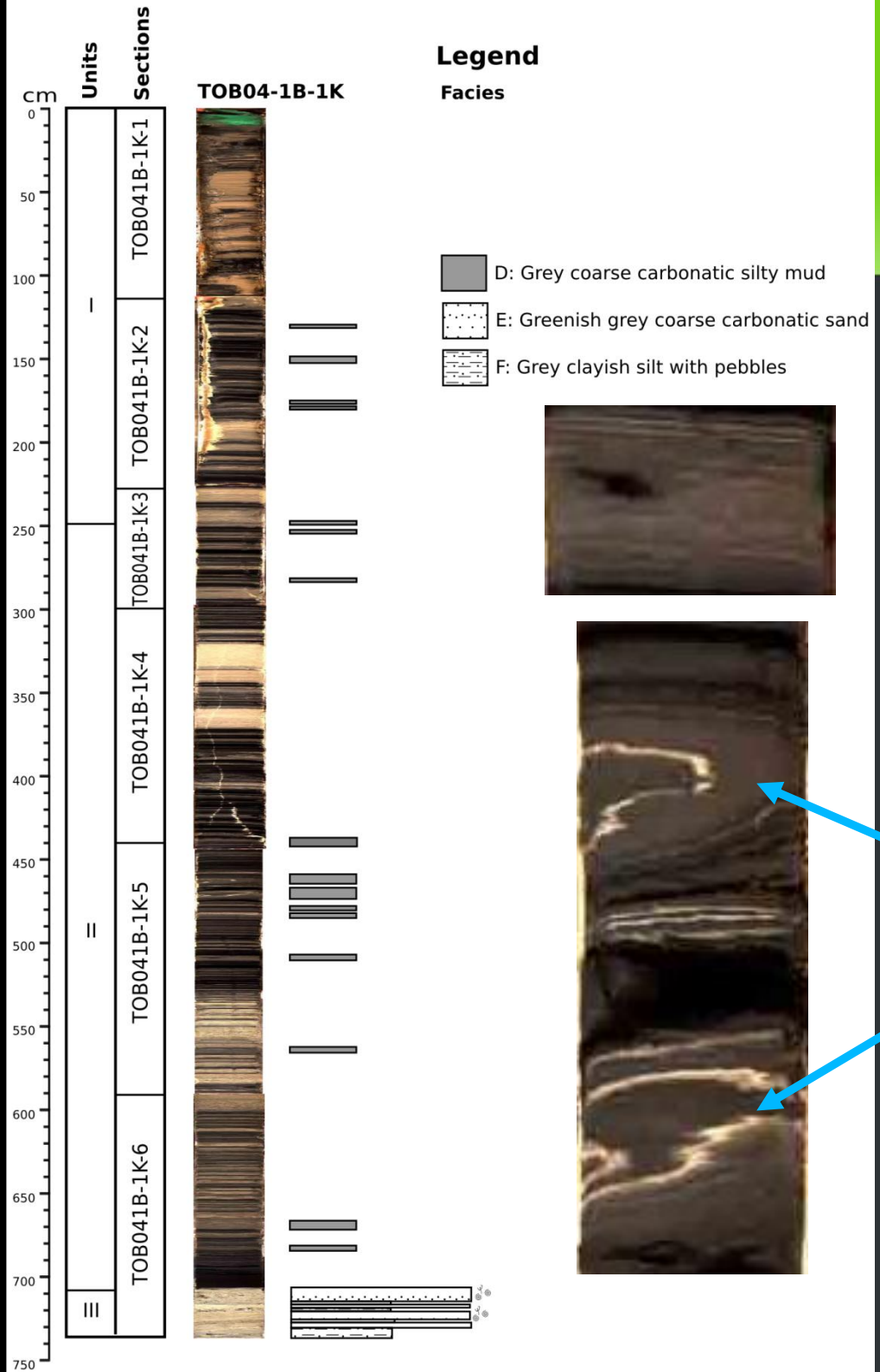

Sedimentology

Facies D: Grey coarse carbonatic silty mud with some Qz, silicates, diatoms and OM. More clastic.

Slumps

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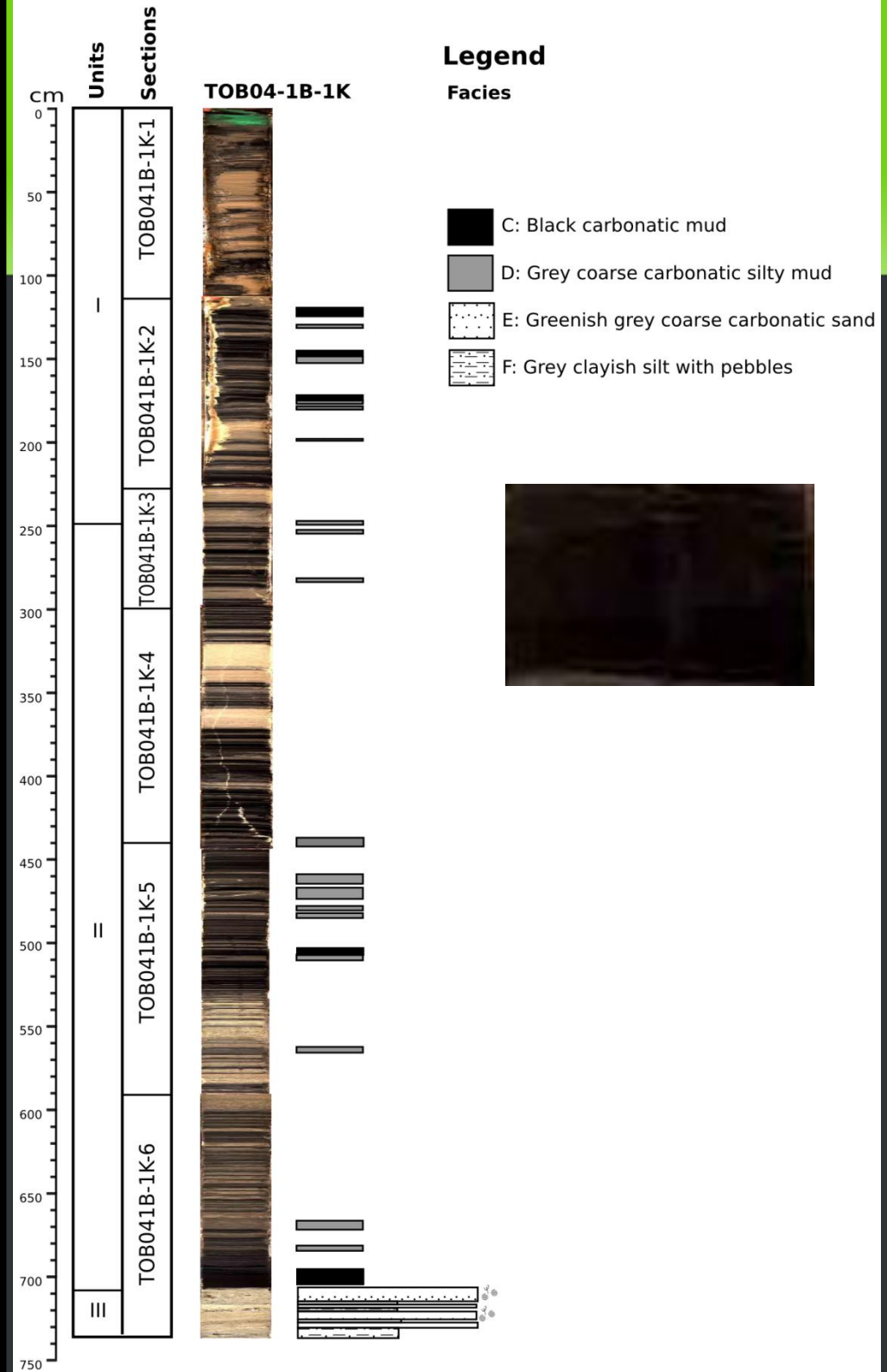

Sedimentology

Facies C: Black carbonatic mud with pyrite, diatoms, amorphous OM and plant remains.

There are two calcite groups: i) small cristals (autigenic) and ii) big ones (detrital).

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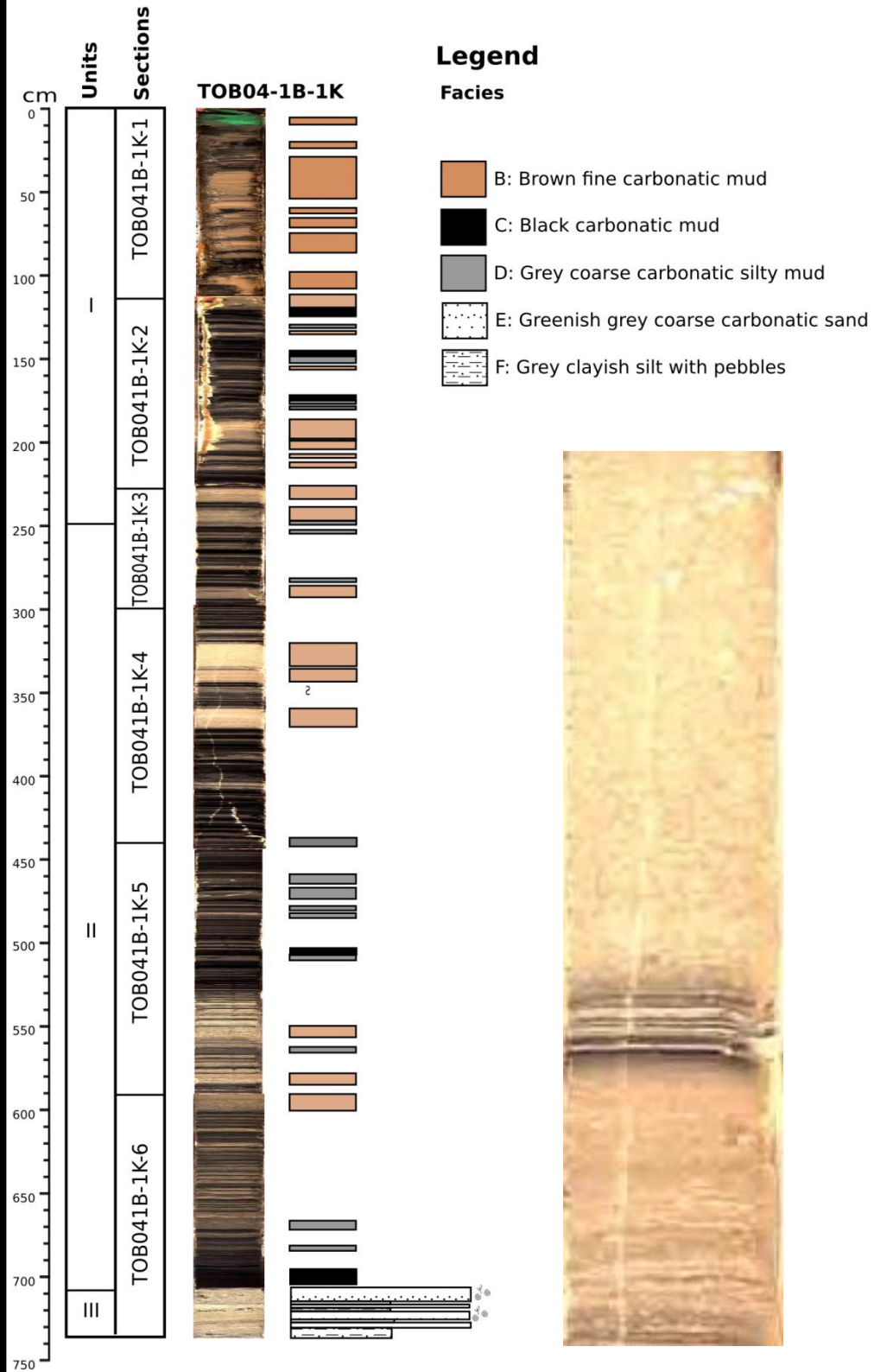

Sedimentology

Facies B: Brown fine carbonatic mud with small Qz cristals, some gypsum, diatoms and amorphous OM.

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Sedimentology

Facies A: Finely laminated carbonatic mud composed by black, brown and grey laminaes:

Black: carbonatic mud with diatoms.

Grey: carbonatic-silty mud with Qz.

Brown: carbonatic mud with Qz.

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Chronology… in progress

- Preliminary AMS 14C dates shows a basal age ca. 100 BC. ^{137}Cs and some chronological markers suggest high sedimentation rates (1cm/yr)

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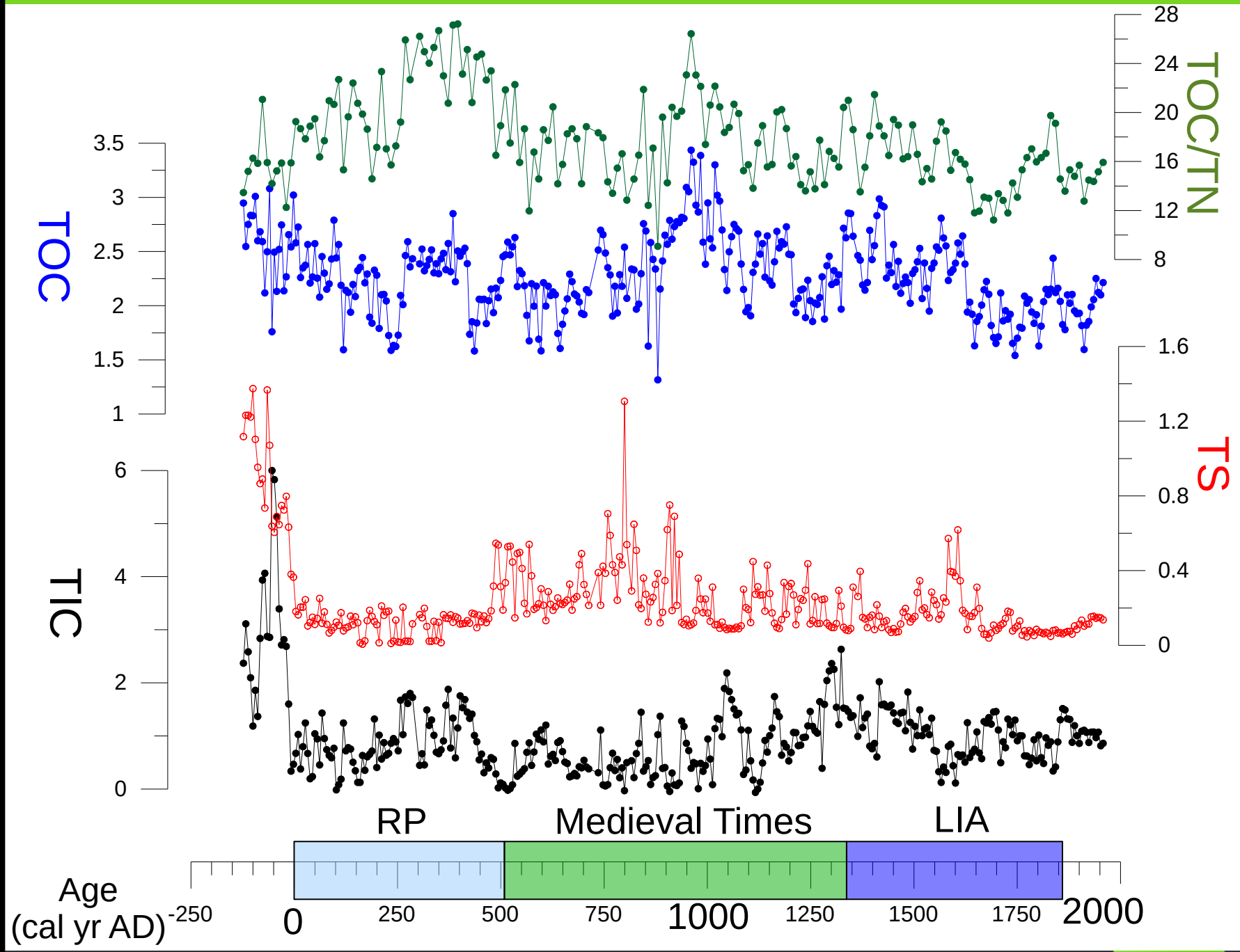
Geochemical proxies



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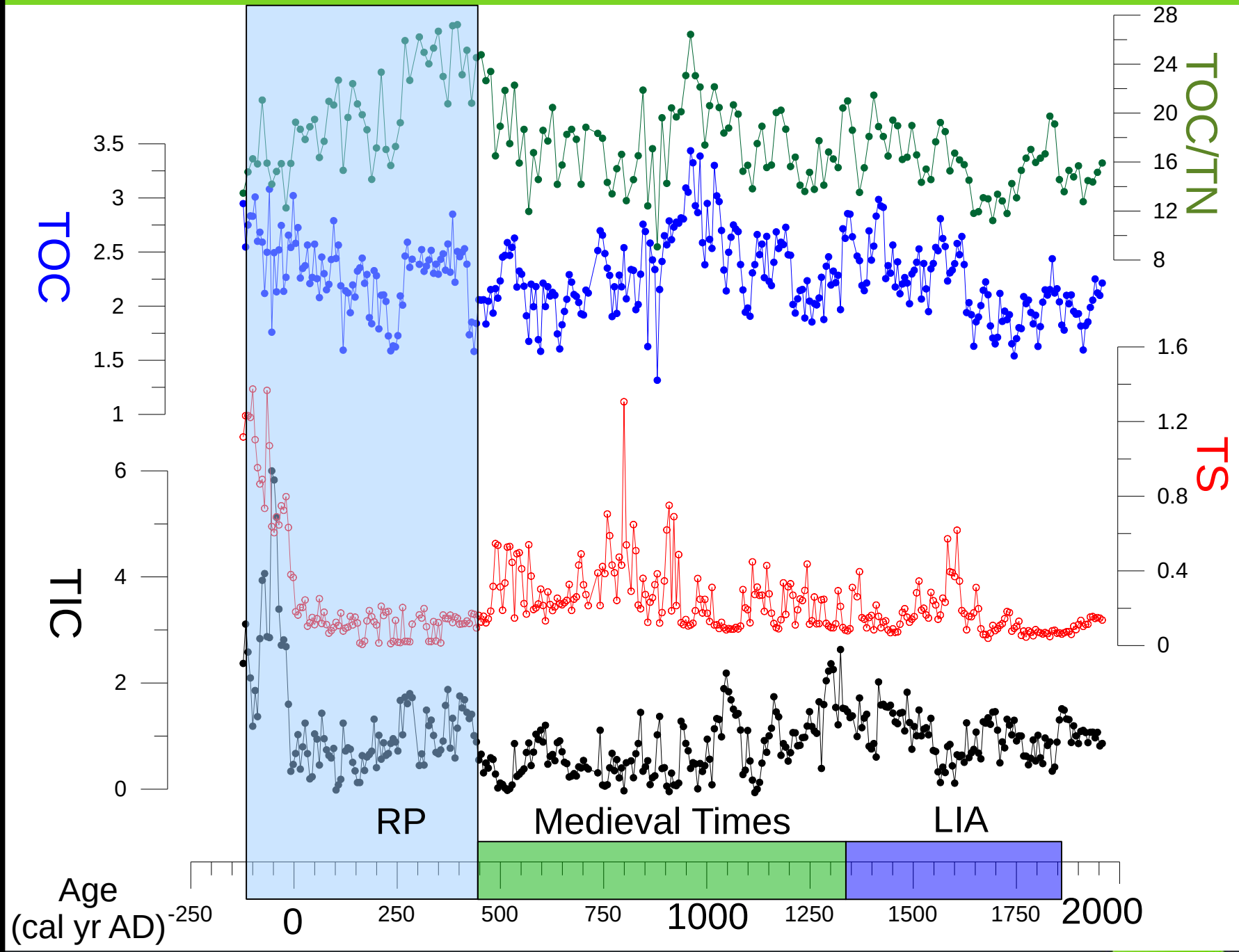
During the RP occurs a rapid transition from a very shallow lake (sands with gastropod and silts facies) to a deep and meromictic lake (laminated facies appear)



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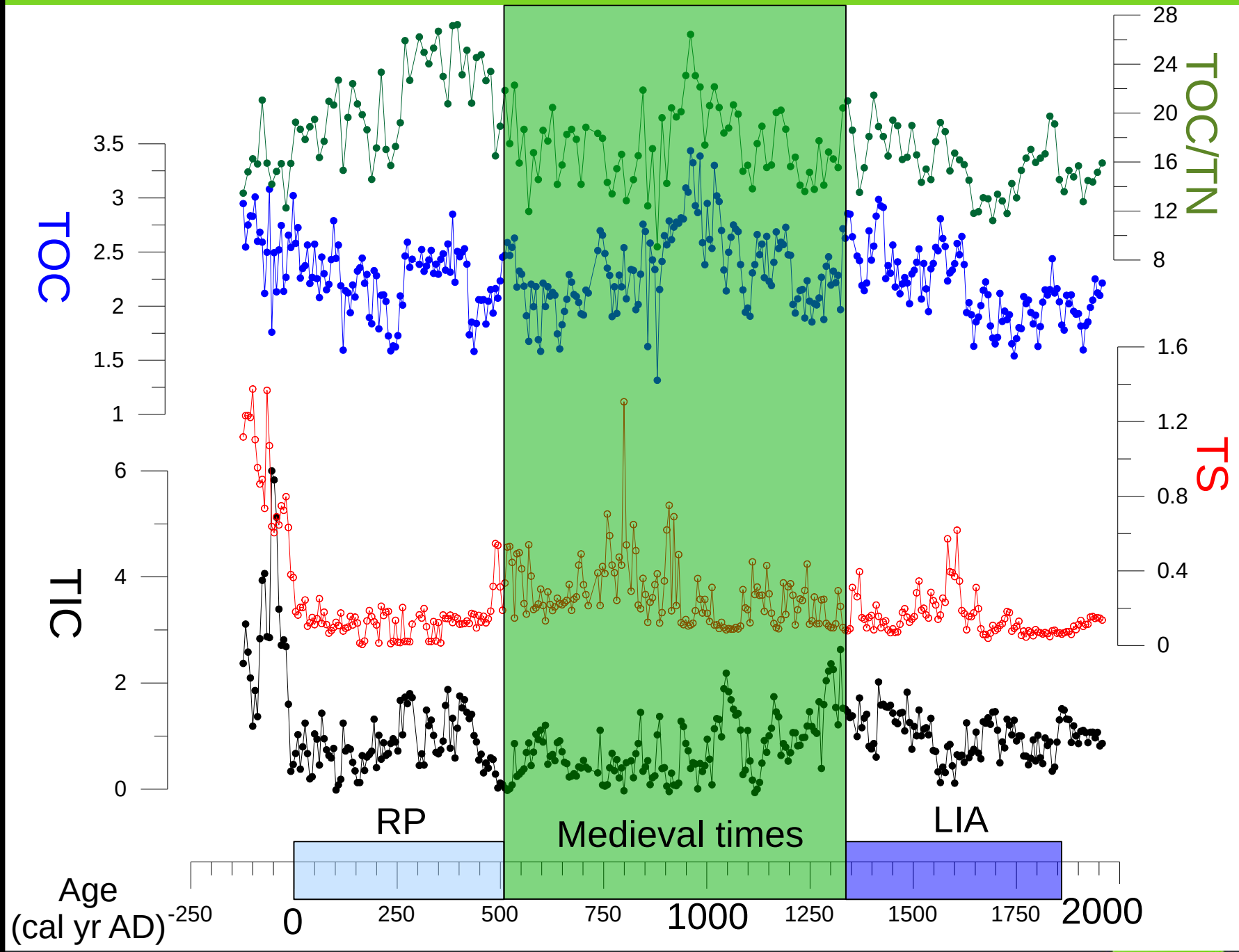
During Medieval times, there is an increase in coarse silt facies and also an increase in gypsum.



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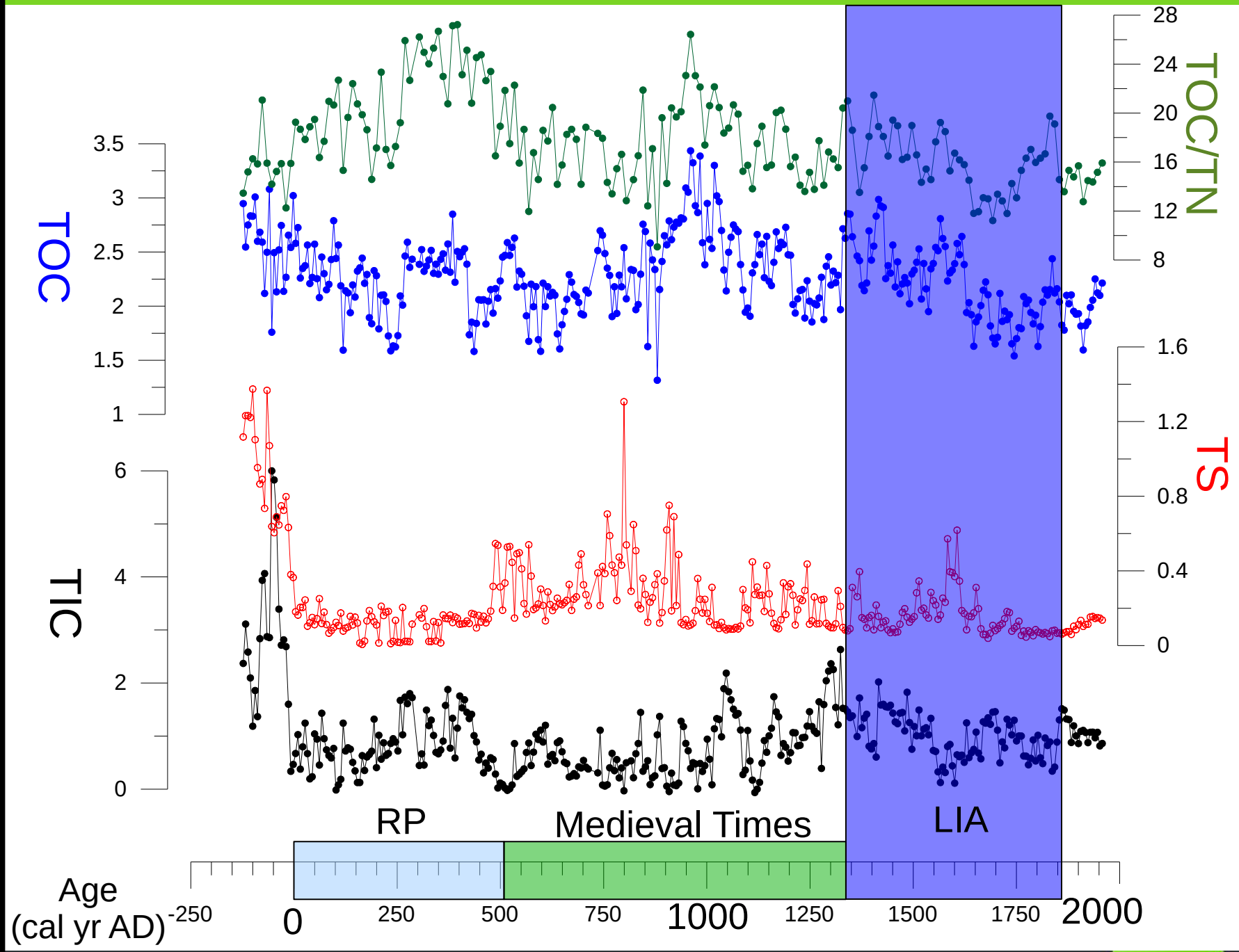
During the LIA , a decrease in clastic facies and a relatively decrease in gypsum occurs.



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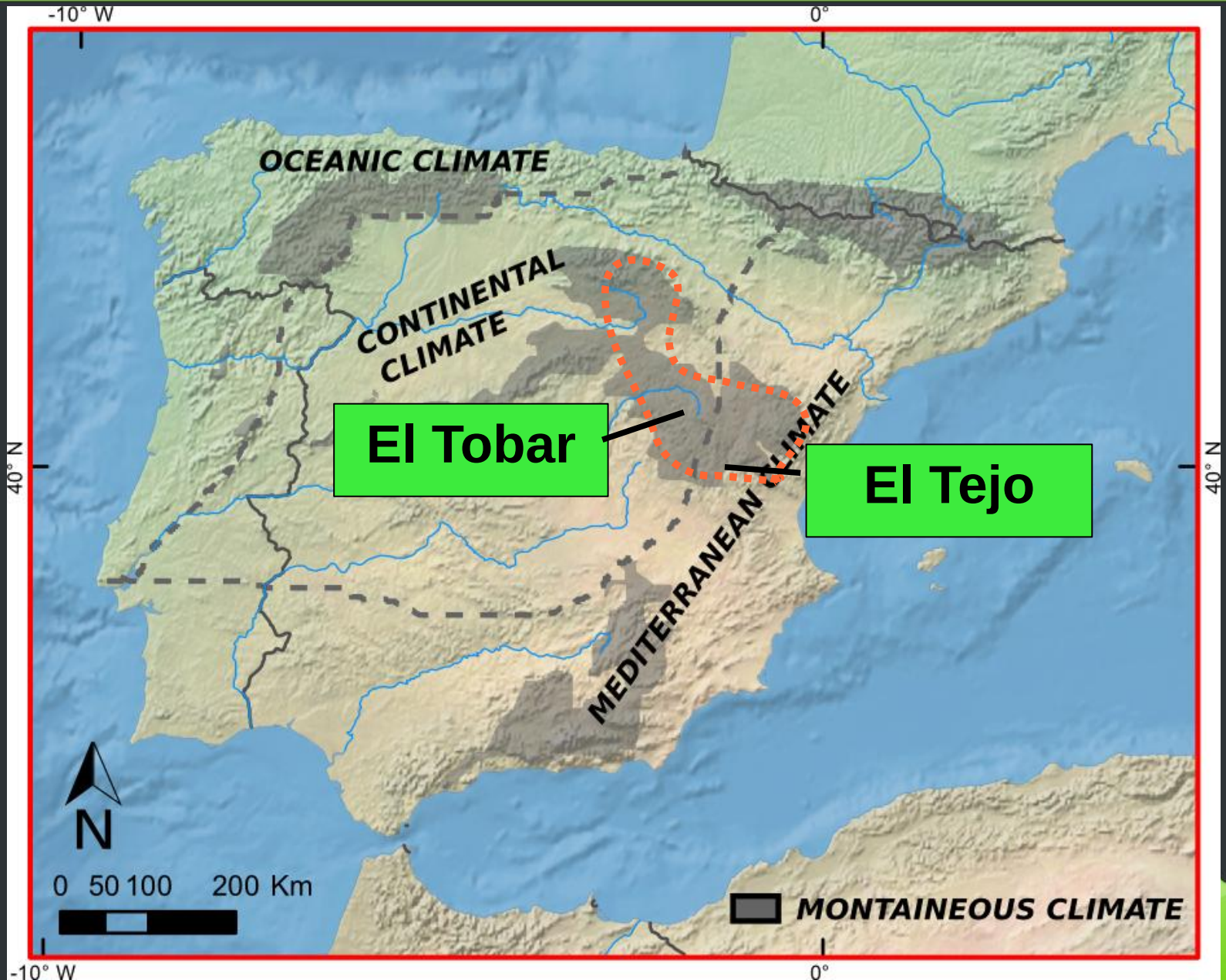
The Lakes



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El Tejo

The deepest lake in the region (28 m)
A doline lake similar to La Parra
The best candidate for varves!

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Introduction
&
Location
El Tobar

El Tejo

El Tejo

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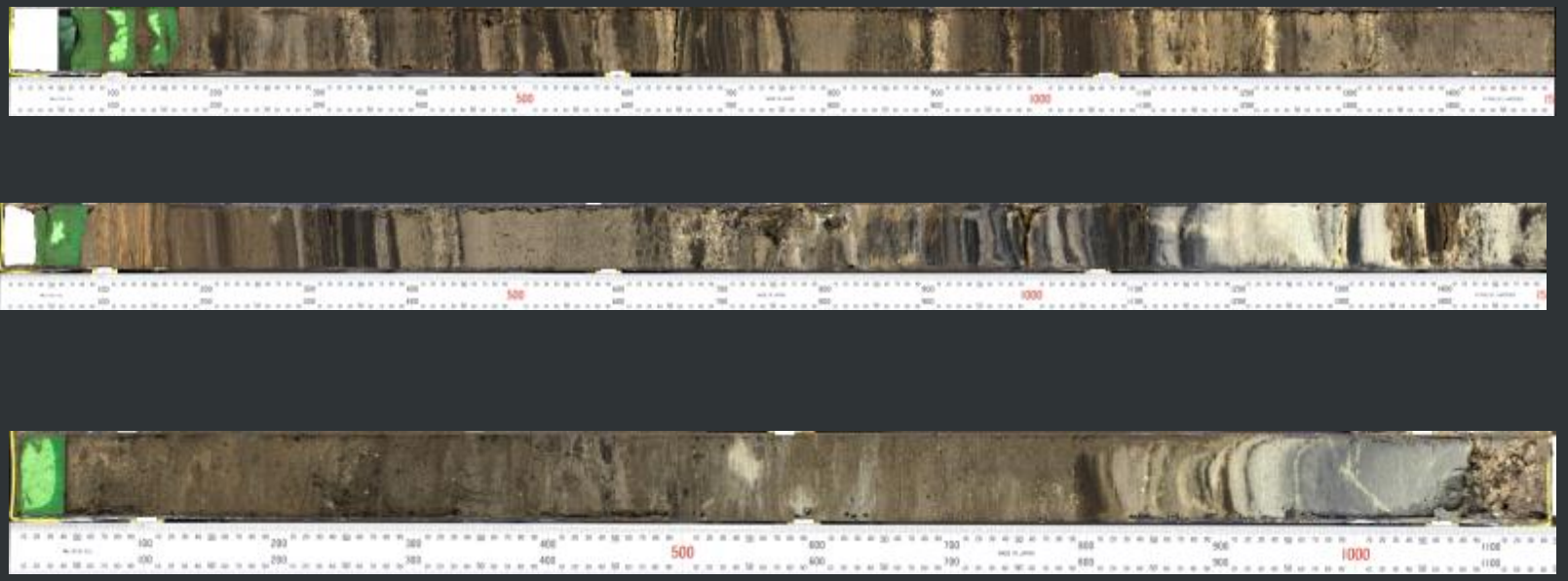
El Tejo



- About 6 m long lake sequence
- Very thin “varved” intervals
- Bottom coarse, shallower facies and sharp transition to deeper water (banded, faintly laminated facies)
- Preliminary dating: transition about 2000 BP

To conclude...

- Iberian Karstic lakes display a large facies variability during the last 2000 years
- Facies and geochemical signatures are valuable paleohydrological (paleoclimate) indicators
- Detail facies models are needed

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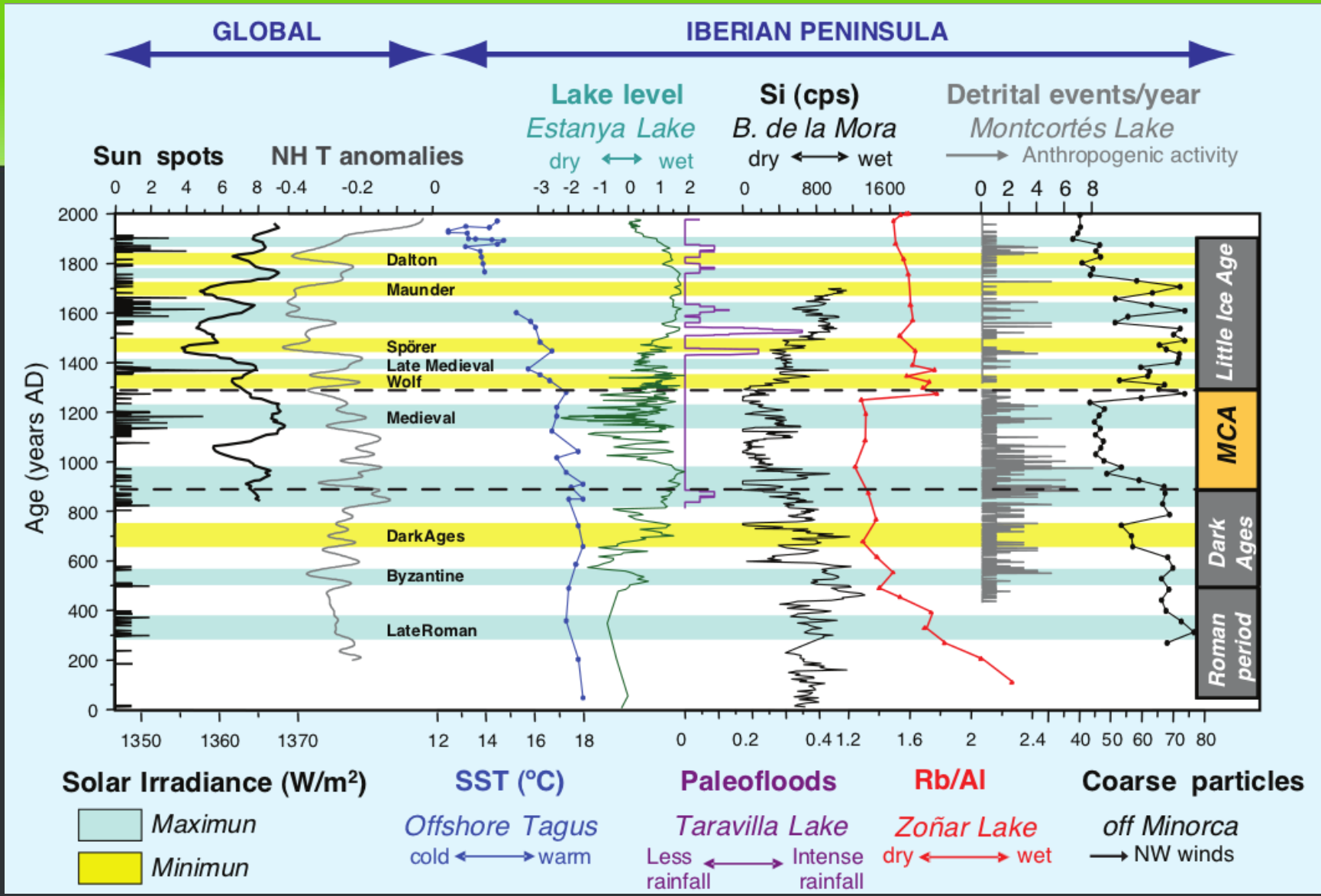
Conclusions

(Moreno et al., 2011)



In the Iberian Peninsula, the IRHP, the MCA and the LIA had a strong impact on the hydrological cycle

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To conclude...

- Intense dry period prior to the Roman Period (or within the RP in southern Spain)

- RP:
- Increase humidity, particularly at the end of the RP
- A significant latitudinal component exits:
  RP wetter in the S than in the N

-The MCA is a drier period

- The LIA is a wetter period with several internal phases

-Human impact:
- 2 periods of increased human activity near the lakes (at the end of the RP and during Medieval times)
- 2 periods of less human impact (during the DA and the LIA)

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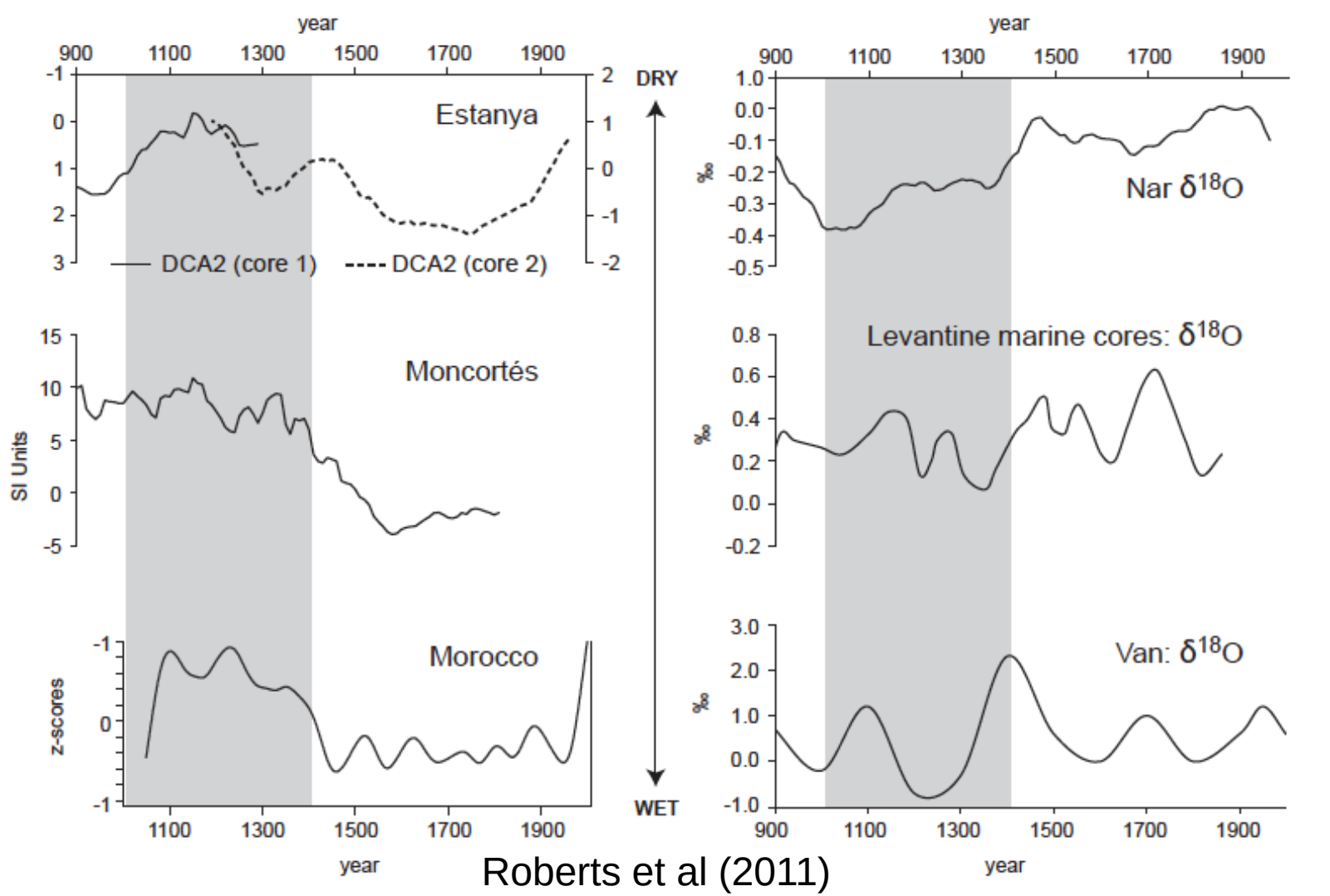
Some global implications…



Roberts et al (2011)

A West – East Mediterranean dipole?

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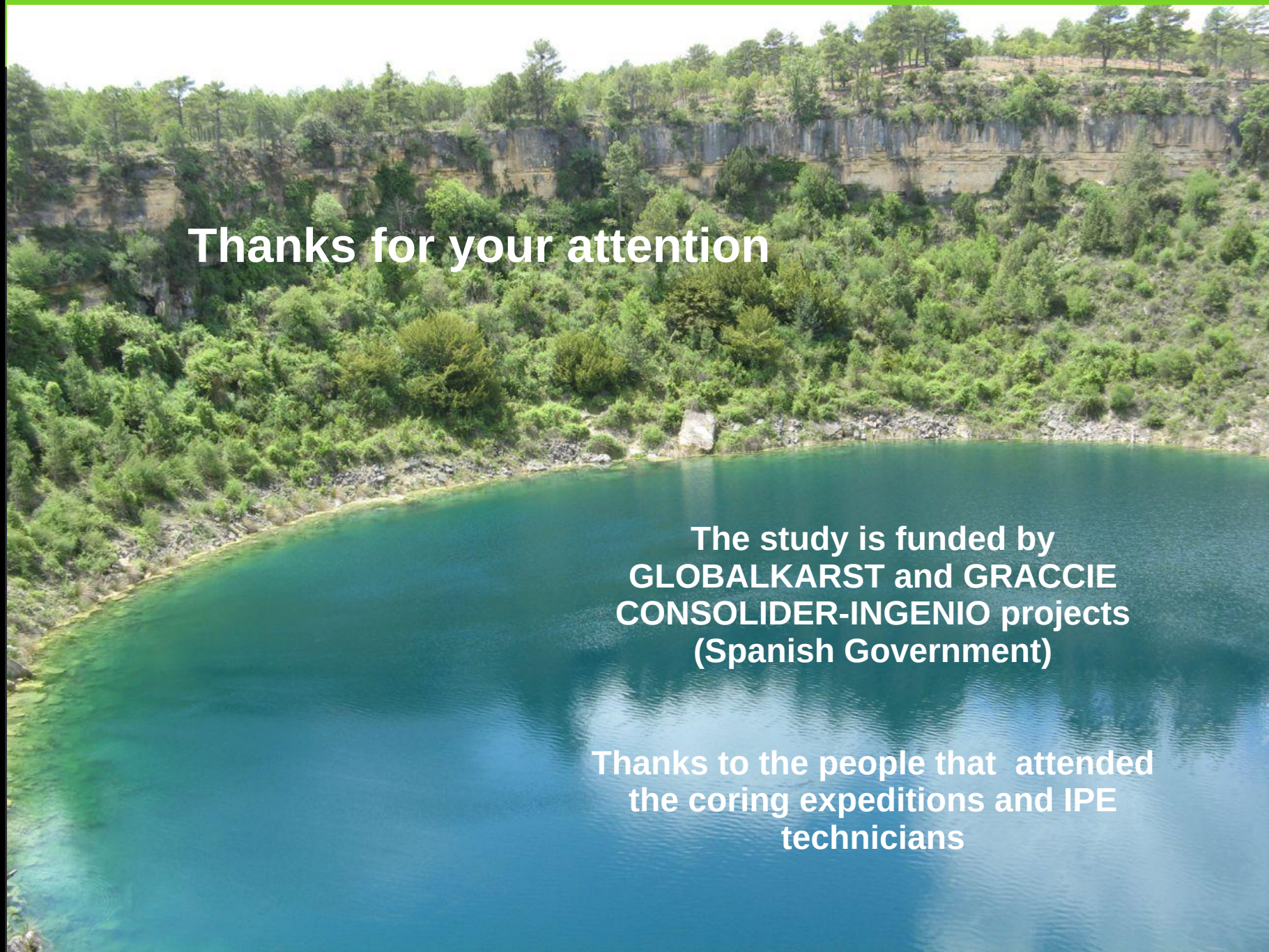
That's All!



Thanks for your attention

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